# NORTHERN GOSHAWK ECOLOGY AND HABITAT RELATIONSHIPS ON THE TONGASS NATIONAL FOREST

## *(GOSHAWK NEST SITES, FOOD HABITS, MORPHOLOGY, HOME RANGE AND HABITAT DATA)*

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1 June 1994

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Dear Mr. ~~Iverson~~ Chris:

I am pleased to provide you with our final annual northern goshawk progress report. I hope that this report meets with your approval. I am grateful for your continued interest, administrative help, and ecological insight. It is considerably more than just being the contract officer and this is a real benefit. The assistance of Gene DeGayner is far more than any of us ever expected. I believe that the professional dedication of individuals such as Gene, Craig Flatten, and Rich Lowell deserve special merit.

I am personally proud of the progress we have made as agencies to share research data in a real-time setting. Clearly, the net benefit will be the resource by using the best of what each agency has to offer.

We are all striving for the best possible information upon which management decisions can be made. As such, this effort is not a classical scientific endeavor where researchers collect data for five years and then spend a few more to write up the results. Myself and others are trying to respond to the necessary management questions in a timely manner, with reasonable, if not perfect analyses. I trust that all who read this report will remember that this is a *progress* report. It is not the final interpretation.

Sincerely,

Kimberly Titus
Regional Supervisor

c: D. Kelleyhouse
J. Capp
A. Kimbell

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## 1. Introduction

As a cosmopolitan species, the northern goshawk (*Accipiter gentilis*; hereafter goshawk) occurs in a variety of habitats, including managed forests of Europe (Kostrzewa 1985), mixed deciduous/coniferous forests of the eastern U.S. (Speiser and Bosakowski 1987), and coniferous forests of the Pacific northwest (Reynolds et al. 1982). Despite the breadth of forests habitats used by this species, local and regional threats have been identified that may result in population declines (Reynolds 1989). Within the western U.S. Reynolds (1989) identified loss of breeding and wintering habitat associated with timber harvest as one threat to accipiter populations, including the goshawk. Goshawks are associated with mature forests of the Pacific Northwest (Reynolds et al. 1982, Moore and Henny (1983) and these forests have undergone extensive timber harvest.

The ecological relationships between forest management, goshawk population size and habitat use away from the nest site are not understood in the Pacific northwest or Southeast Alaska. Ecologists have recognized the concept of managing landscapes for forest raptors beyond their nest site (e.g., Kenward and Widén 1989, Crocker-Bedford 1990, Nelson and Titus 1989, Thomas et al. 1990, Reynolds et al. 1992). Integration of the concepts of managing forests at the landscape-level may be required for goshawks and other wide-ranging species in order to maintain biodiversity amidst ecological patterns and processes that are complex and poorly understood (e.g., Franklin 1993).

Goshawks occur in low densities in the rainforests of southeast Alaska. Our studies of this species on the Tongass National Forest continue with an ecological emphasis in order to provide the basis for meeting administrative objectives associated with forest management. The National Forest Management Act, USFS Sensitive Species designation, Alaska Department of Fish and Game Species of Special Concern designation, and Endangered Species Act require biological information about uncommon species such as the goshawk for assistance with resource management decisions. Ecological reasons for studying the goshawk include assessing its association with mature/old-growth forests, landscape use patterns within an insular and fragmented archipelago, and phenotypic affiliations of a described *A. g. laingi* subspecies in southeast Alaska. Our objectives are guided by the paradigm that better ecological information will lead to informed administrative decisions over the allocation and conservation of old-growth forests that maintain goshawk populations (e.g., Romesburg 1991, Irwin and Wigley 1993).

### Report Objectives

This report is a compilation of the December, 1993 Progress Report and the April, 1994 Final Annual Project Report, as described in the 1993 Study Plan (ADF&G 1993*a*). Acceptance of this report satisfies the terms of contract number 43-0109-3-0272.

The current study of goshawk ecology and habitat relationships on the Tongass National Forest is a continuation of the ADF&G - USDA Forest Service cooperative effort concerning this species begun in the summer of 1991.

The 1993 Study Plan (ADF&G 1993a) lists the following study objectives:

A. Locate additional goshawk nest sites and characterize nest site habitat components.

B. Determine goshawk home ranges and habitat associations using radio-telemetry.

C. Evaluate the diet of goshawks during the nesting period.

D. Determine short-term dispersal distances and survival rates of juvenile goshawks when possible.

E. Assess subspecific variation in *A.g. laingi* for Southeast Alaska.

We present progress and findings from efforts addressing these objectives, including: activity status of goshawk nest sites (objective A), characterization of nests sites (objective A), description of breeding season food habits (objective C), analysis of morphological data (objective E), genetic analysis of blood samples (objective E), analysis of radio-telemetry data (objective B), and fledging, dispersal, and survival of juveniles (objective D).

## 2. Nesting Activity

### A. Nest Areas and Nest Sites

We defined the nesting area as a forested stand and general area (e.g., ≈20 ha) that may contain ≥ 1 known nest tree. Areas with aggressive adult behavior or the presence of fledglings also constitute a nesting area. Vague descriptions, repeated goshawk sightings in a locale, and the presence of stick nests without additional evidence of goshawk nesting were not included in our criteria of a goshawk nesting area.

We defined a nest site as a known goshawk nest tree and a one hectare area surrounding the tree (cf. Mosher et al. 1987).

### B. Status

Field activities and a review of records documented a total of 21 nest areas in Southeast Alaska with northern goshawk nesting activity since 1990 (Table 1). In the Ketchikan, Stikine, and Chatham Areas of the Tongass National Forest, a total of four, nine, and eight

nesting areas, respectively, have been identified through the 1993 breeding season. At least one nest site has been located at 18 (80%) of these 21 sites. Nests have not been located at three areas, but nesting activity is implied here by aggressive behavior of adult goshawks and/or the presence of fledglings.

Factors affecting the ability to accurately determine the activity status of goshawk nesting areas include observer experience, search intensity, phase of nesting chronology and responsiveness of goshawks to conspecific calls (Kennedy and Stahlecker 1993, Kimmel and Yahner 1990). Alterations in forest structure caused by timber harvest (Crocker-Bedford 1990), stand size and the level of landscape fragmentation (Woodbridge 1988), and annual fluctuations in the abundance of prey (McGowan 1975), and adult mortality influence whether goshawks reoccupy a particular nest site or area. Breeding goshawks may use the same nest for a number of years, build a new nest in the same or different stand, or reoccupy an old nest. Alternate nests may be loosely clustered within a single stand or widely separated in different stands (McGowan 1975, Beebe 1976, Woodbridge 1988). In Southeast Alaska, site accessibility, inclement weather, and dense temperate rainforest vegetation are additional factors affecting an observer's ability to assess the activity status of goshawk nest sites.

In 1993, ADF&G and USFS biologists visited 18 nesting areas ≥1 time. Eleven (61%) nesting areas were previously known and seven (39%) were new sites located in 1993 (Table 1). Of the 11 previously known nesting areas visited in 1993, goshawk activity was documented at five (45%). These included two areas (Big John Creek, Point Bridget) where an active nest was located, and three areas (Port Refugio, Sarheen, Falls Creek) where an active nest was not located, but goshawks were observed and/or responded to conspecific calls.

Eight active nests were documented at seven Southeast Alaska areas between 1989 and 1992. In 1993, seven of these nests were checked and none was active, however, an active alternate nest was found at two areas (Big John Creek, Point Bridget). At both of these sites, the active nest was located in the same stand as the previously year's active nest. It is not known if these alternate nests were constructed in 1993, or were reoccupied old nests that were not detected during previous searches. We have not observed reoccupancy of a previously known active nest.

Distances between alternate nests vary widely. In a goshawk study in northern California, Woodbridge (1988) and other biologists color banded 140 goshawks, including 48 adult and 92 young, over a four year period during which 178 nesting attempts were monitored. During successive years they were able to monitor inter-year nest movements of 36% and 82% of marked goshawk pairs on two Forest Service districts. Nesting goshawks were relocated by intense surveys (without radio-telemetry) and the success of nest relocation depended on the intensity of nest monitoring and search efforts. In their study, color banded goshawks were relocated on 30 occasions when they moved to an alternate nest in successive years. Mean distance moved by relocated individuals was 0.6 km (0.36 mi), with a range of 80 m (0.05 mi) to 2.8 km (1.7 mi). Median distance moved was 0.24 km (0.15 mi), and seven pairs

(23%) moved more than 0.8 km (0.5 mi). The frequency at which pairs reoccupied the same nest in successive years and the percentage of color banded birds not relocated each year, were not given.

In Southeast Alaska, a total of seven instances of renesting in successive years was documented between 1992 and May, 1994 (Table 2). These include five sites where the active nest was located in the same stand in successive years, and two sites where the active nest was located in different stands in successive years. Results from radio-tagged adults confirmed that at least one member of the previous year's nesting pair was present at one of the five same stand reoccupancies. At four of the five same stand reoccupancies, the identity of the adults is unknown. All seven active nests located the second year were in different trees than the active nests of the first year. None of the second year nests was previously known and it was not determined if these had been newly constructed when located, or were reoccupied old nests.

We found that the distance moved between nests occupied in successive years ranged from 120 m (0.08 mi) to 24 km (15 mi). At five of seven sites distance moved was between 120 m (0.08 mi) and 350 m (0.22 mi), while at the other two sites the distance moved was > 3.2 km (2.0 mi). Three of the seven second year nests were located via searches unaided by telemetry, while four nests were located by tracking radio-tagged adult females. The smallest distance moved to a new nest located with telemetry was within the range of distances moved to new nests located without telemetry. However, the largest distance moved to a new nest located with telemetry was 68 times the largest distance moved to a new nest located without telemetry. This indicates that reliance on searching known goshawk nesting areas on the Tongass National Forest provides only limited information about adult survival and patterns of nesting ecology. While individual nests and nest stands can be checked annually to determine presence or absence of nesting goshawks, it is difficult to confidently establish the activity status of goshawk territories or assess goshawk populations based on observed nest site occupancy alone. The low densities and wide-ranging movements of goshawks in southeast Alaska will continue to preclude the short-term development of a suitable sample size of nest sites from which to draw statistical inferences regarding goshawk population ecology. Continued monitoring of radio-tagged adults will provide information on nesting, movements, home range, and habitat associations.

## 3. Nest Site Characterization

A total of 25 goshawk nests at 22 nest areas have been documented in Southeast Alaska (Table 1). Selected habitat attributes characterizing 18 nests at the thirteen nest areas in the Ketchikan, Stikine, and Chatham Areas of the Tongass National Forest indicate that nest sites in our sample were located in mature, coniferous forest (Table 3). Fifteen (83%) nests were located in old-growth stands and three (17%) were located in 90+ year old second growth stands. Sixteen (89%) nest trees were in old-growth and two (11%) were 90+ year old second growth.

Based on our sample (n = 18), elevation was relatively low, ($\bar{x}$ = 129 m; 423 ft), ranging from 18 m (60 ft) to 229 m (750 ft) (Table 3). Ground slope at the nest tree was flat to moderately steep ($\bar{x}$ = 19°; range 0 - 36°). Slope aspect was variable through all cardinal directions, however, the range of 12 of 18 nest slopes was from the north-northeast (22°) to east-southeast (112°). Aspect of the nest on the nest tree was also variable, but all nests were oriented between the northeast (45°) and west-southwest (248°). No nests were oriented from west to north-northeast.

Four species of nest tree were documented. Of 18 nest trees, 10 (56%) were Sitka spruce (*Picea sitchensis*), six (33%) were western hemlock (*Tsuga heterophylla*) one (5.5%) was a western red cedar (*Thuja plicata*), and one (5.5%) was a yellow cedar (*Chamaecyparis nootkatensis*). Nest tree diameter at breast height (DBH) was fairly large [$\bar{x}$ = 79 cm (31 in)] and ranged from 41 cm (16 in) to 130 cm (51 in). Mean nest height was 13.7 m (45 ft) ranging from 9.1 m (30 ft) to 25.7 m (84 ft).

Most of the nest sites were located in old growth forest stands and fit the nesting patterns of the Pacific Northwest described by Reynolds et al. (1982) and Moore and Henny (1983). Nest tree DBH was larger in Southeast Alaska than in northeast Oregon. No nests were found on very steep slopes. The visual "gestalt" of goshawk nest sites in Southeast Alaska is broad in that moderate to high basal area old-growth forest stands on flat to moderate slopes with an open subcanopy layer may be used for nesting.

## 4. Food Habits

### A. Identification of Prey Remains

The study of raptor diets provides some understanding of raptor niches and how they relate to raptor community structure, and provides valuable information on prey distribution, abundance, behavior, and vulnerability (Johnson 1981, *in*: Marti 1987). Knowledge of the goshawk's diet is also an important component of management plans for this species (Reynolds et al. 1992).

Goshawks typically pluck plumage and pelage from their prey in the nesting area or on the nest itself, leaving remains such as feathers, fur, and bones (Palmer 1988). Prey remains can generally be located on the nest and on or below plucking perches within 100 m of the nest tree (pers. obs.). Since 1989, remains have been collected at a total fifteen goshawk nest sites in Southeast Alaska, including three sites in the Ketchikan Area, five sites in the Stikine Area, and seven sites in the Chatham Area. Prey remains were collected at eight nest sites in 1993 (Table 4).

A gross examination of prey remains from each nest site was conducted to determine the presence of readily identifiable species. This analysis was restricted to identifiable feathers, fur, and carcass fragments. It is generally impossible to count the number of individuals in samples of prey remains when the method of identification is by hair or feather analysis

(Marti 1987). Quantification of raptor diets based on examination of these kinds of prey remains is, therefore, limited to expressions of the relative presence frequency of each prey species or other taxon.

Steller's jay (*Cyanocetti stelleri*; 100%), grouse (*Dendragapus* sp.; 73%), varied thrush (*Ixoreus naevius*; 60%), red squirrel (*Tamiasciurus hudsonicus*; 47%), and woodpeckers (Picidae; 40%) represent the five prey most frequently identified at nest sites (Table 4). We believe these prey species represent the majority of biomass in the diet of goshawks nesting in Southeast Alaska. Beebe (1974) states that *laingi* goshawks of the Queen Charlotte Islands live mostly on northwestern crows (*Corvus carinus*) which are captured over beaches adjacent to dense coniferous rainforest. For goshawks in Southeast Alaska, northwestern crow was identified in prey remains from only two of 15 (13%) nest sites (Tables 4 and 5). Beebe (1974) also states that goshawks living on Vancouver Island live mostly on Steller's jay and varied thrush. This description more closely parallels the prey we identified at Southeast Alaska nest sites.

Johnsgard (1990) states that gallinaceous birds such as grouse and ptarmigan are typically the most important avian prey for goshawks, as they are often found in comparable habitat and frequently can be captured in flight or on the ground. Grouse (*Dendragapus* sp.) were identified in remains from 73% of Southeast Alaska nest sites, and ptarmigan (*Lagopus* sp.) were identified in remains from 13% of nest sites (Table 5). With the possible exception of a waterfowl (Anatidae sp.) collected in remains, these birds represent the largest avian prey identified at Southeast Alaska nest sites. The overall large quantity of grouse remains collected at nest sites indicates that this avian group may represent the most significant portion of the breeding diet biomass of goshawks from this region.

Red squirrels (*Tamiasciurus hudsonicus*) were identified in prey remains collected from 47% of nest sites. With the exception of *Lepus* sp. remains identified at one site, red squirrels represent the only mammalian species identified in gross examination of prey remains (Tables 4 and 5). Squirrels and chipmunks (e.g., *Tamiasciurus*, *Tamias*, *Sciurus*, *Glaucomys*, *Eutamias*, *Spermophilus*) are important goshawk prey in some areas such as eastern Oregon (Reynolds and Meslow 1984) but only the red squirrel and northern flying squirrel (*Glaucomys sabrinus*) occur in Southeast Alaska and each has a patchy distribution across the Alexander Archipelago.

## B. Discussion

In assessing the diet of nesting northern goshawks, it is important to recognize possible biases associated with methods relying on the collection and identification of prey remains from nest sites. For example, because plucked feathers from avian prey are often scattered and, therefore, more visible than remains from mammalian prey, identification of remains collected at the nests of goshawks and other *Accipiters* may be biased toward avian species (Bielefeldt, et al. 1992, Mersmann et. al. 1992, Ziesemer 1981).

Collected prey remains may also be biased toward more colorful or larger species. For example, the bright blue plumage of the Steller's jay (*Cyanocitta stelleri*) is probably more visible and therefore collected more frequently than the remains of less colorful prey. Similarly, the remains of grouse (*Dendragapus sp.*), which are relatively large, are probably more visible and more frequently collected than remains of smaller species (e.g., woodpeckers). Smaller prey items such as passerines may be consumed entirely, leaving few or no remains (Bielefeldt, et al. 1992).

Assessment of goshawk diet based on prey remains from nest sites may also be biased due to differences in prey selection by male and female *Accipiters* (Reynolds and Meslow 1984, Newton 1986, Bielefeldt et al. 1992). Because adult male goshawks typically provide the majority of prey delivered to the nest between the pre-incubation to fledging period, prey remains collected at nest sites more accurately represent prey captured by adult males than their nest-tending mates (Reynolds and Meslow 1984).

While prey species identified from remains collected at nest sites may portray the diet supporting the family group during the breeding season, they probably do not represent the year-round diet of resident goshawks due to seasonal changes in the abundance and availability of prey. For example, some important avian prey species which are seasonal migrants (e.g., sapsuckers, shorebirds, passerines) are unavailable to resident goshawks during the winter. This seasonal reduction in prey availability may be one factor limiting resident goshawk populations in Southeast Alaska.

Regional differences in prey composition and abundance may also influence goshawk populations. For example, small mammals (particularly *Sciurus sp.*) have been identified as a major component of the diet biomass of nesting northern goshawks in other regions (Kennedy 1989 and 1991, Reynolds et al. 1992, and Mannan and Boal 1993). Southeast Alaska supports relatively few small mammals species that are available to goshawks as prey and these species, such as the red squirrel (*Sciurus hudsonicus*) have limited distributions and occur in relatively low numbers. Gross analysis of prey remains collected from nest sites suggests goshawks residing in Southeast Alaska rely primarily on avian species for the majority of biomass in their breeding season diet. In contrast, in the southwestern U.S. small mammals make up the majority of the species identified as prey at nests and may represent up to 80-90% of biomass (Kennedy 1989, Reynolds et al. 1992, and Mannan and Boal 1992). Kenward (1982) and Newton (1986), and others found that prey abundance and availability were important factors in determining accipiter nesting densities. The relative paucity of small and medium-sized mammals available as goshawk prey in Southeast Alaska compared to other regions may be a factor limiting goshawk populations.

Several prey species of special interest have been identified from remains collected at nest sites in Southeast Alaska. Sharp-shinned hawk (*Accipiter striatus*) remains have been identified at four goshawk nest sites. Alcid remains, believed to be those of marbled murrelet (*Brachyramphus marmoratus*), were identified at three nest sites. Other species include a northern saw-whet owl (*Aegolius acadicus*) and a beetle (*Coleaptera sp.*).

## 5. Morphology

Taverner (1940) originally described the Queen Charlotte goshawk, *A.g. laingi*, as a mostly non-migratory goshawk subspecies of the islands of coastal British Columbia (see below, B. Plumage). The type specimen was collected from the Queen Charlotte Islands, located approximately 30 miles across Dixon Entrance from Southeast Alaska. Following the examination of goshawks collected in Southeast Alaska, Webster (1988) reported that based on the dark coloration of these specimens, the range of *laingi* extends north from the Queen Charlotte Islands as far as Baranof Island and Taku Inlet. The U.S. Department of Interior's Habitat Management Series for Unique or Endangered Species Report No. 17 (Jones 1981) shows the range of *laingi* extending north to Prince William Sound.

Whaley (1988) has shown mensurally that goshawk morphometrics vary regionally in North America, and that goshawks from the range of *laingi* average smaller in size than goshawks from other areas. He also found that a cline of increasing size occurs between the Pacific Northwest coast of Washington and southern British Columbia, and the Yukon Territory and interior Alaska. He indicated that this cline was probably a continuum through northern B.C. and Southeast Alaska, but it was not verified due to the paucity of museum specimens from these regions.

Variation in phenotype has been documented in goshawks from coastal B.C. and Southeast Alaska, but it has not been well studied. In his northern extension of the *laingi* range to Southeast Alaska, Webster (1988) noted that while the specimens he examined here were as dark as *laingi* specimens from Vancouver Island, they were not as black as those from the Queen Charlotte Islands. Additionally, Taverner (1940) observed that plumage darkening in juvenile goshawks from Vancouver Island was less and more variable than that of juveniles from the Queen Charlotte Islands (see below, B. Plumage). Swarth (1911) observed dark and light individuals among juvenile goshawks collected in Southeast Alaska in late summer.

One objective of our study was to examine the presence of *laingi* goshawks in Southeast Alaska. We compared morphological data collected from individuals throughout the region with the similar information reported for *laingi* in the literature. Additionally, we wanted to examine the presence of latitudinal variation in goshawk morphology within Southeast Alaska, as has been previously indicated by others.

Morphological data has been collected from 41 northern goshawks from Southeast Alaska since 1991. This included 9 adult males, 10 juvenile males, 9 adult females, and 13 juvenile females. Thirty-five of these individuals were captured at active nest sites and were, therefore, known residents. This group included 9 adult males, 8 juvenile males, 8 adult females, and 10 juvenile females. Six specimens, including 2 juvenile males, 1 adult female, and 3 juvenile females, were collected as mortalities during other times of years. The natal origin of these specimens was unknown. Standard avian morphological measurements were collected from all individuals, including: mass, wing chord, wing flat, wing arc, standard tail length, uropygial tail length, hallux, foot span, talon spread, tarsus length, tarsus width, tarsus

depth, culmen and beak. Additionally, all goshawks captured at nest sites were photographed to document plumage coloration and markings.

Morphological data from each individual was assigned to one of four age-sex groups to account for variation in northern goshawk size and plumage attributable to age and sex (Brown and Amadon 1968, Mueller et al. 1976, Kemp 1987). These groups include: adult male, juvenile male, adult female, and juvenile female. Adults were distinguished from juveniles by the distinct plumage change occurring in northern goshawks at one year of age. Reversed sexual size dimorphism in accipiters is great (Brown and Amadon 1968) and males are typically smaller in overall size than females. Males and females of both age groups were distinguished by standardized sex specific wing chord and tail measurements (U.S. Fish and Wildlife Service, 1991). Only individuals captured at active nest sites were included in the initial data set (n = 35). This was done to insure that the sample was representative of goshawks resident to Southeast Alaska and did not include birds from other regions.

To examine possible latitudinal variation in goshawk morphology, we arbitrarily divided Southeast Alaska into three areas of approximately equal north-south extent. These areas are: 1.) south of 56° 00'N (approximately Coffman Cove on Prince of Wales Island), 2.) 56° 00' to 57° 30'N (approximately Coffman Cove to Angoon on Admiralty Island), and 3.) north of 57° 30'N (Angoon). Morphologic information from each goshawk was assigned to one of these three areas based on the location of the nest site at which it was captured. Mean measurements and photo records of goshawk plumage were compared between these areas, and to similar information reported for *laingi* goshawks in the literature. In addition to examining possible variation in goshawk size and phenotype, this latitudinal analysis of Southeast Alaska data in effect morphometrically examined Webster's range extension of *laingi*, which was based on phenotype, by comparing individuals from northern Southeast Alaska --some of which are from near Taku Inlet, with southern individuals-- some of which are from within a hundred miles of the Queen Charlotte Islands. The distance between the most northern and southern nest sites was approximately 325 km (203 mi).

### A. Morphometric Data

Table 6 summarizes the means of eight morphometric variables collected for all individuals in each goshawk age-sex group. Johnsgard (1990) gives the average and range of wing, tail, and mass for male and female northern goshawks as a general reference to the reported size and weight of the northern goshawk throughout its North American range (Table 7). Comparison of Tables 6 and 7 shows that the size and weight of Southeast Alaska goshawks fall within the values reported generally for northern goshawks.

Whaley (1988, p. 22) cites numerous researchers in noting that wing chord is recognized as a good indicator of the body size of birds. In a comparative analysis of morphometric data collected from study skins of North American goshawks, Whaley used wing chord and other measures to determine that *laingi* goshawks average smaller in size than goshawks of the

other North American races. We examined the relative size of goshawks from Southeast Alaska by comparing mean wing chord of individuals within this region with those reported by Whaley and other researchers for the three North American subspecies: *A.g. laingi*, *atricapillus*, and *apache* (Table 8, Figures 1 and 2). We did not use inferential statistical tests pending larger sample sizes.

1. *Comparison within Southeast Alaska*

Within Southeast Alaska, there was variation between the goshawk wing chord means of areas 1, 2, and 3. Means for adult males and females, respectively, increased from Area 1 (south) to Area 3 (north)(Figures 1 and 2). Though sample size of both adult male and female groups was small (8 and 9, respectively) and there was variation in the size of the standard deviations, the trend from slightly smaller individuals in the south to larger individuals in the north is apparent for both sexes (Figures 1 and 2). This trend is supported to a lesser degree by the observation that mass and tail length of adult male and female goshawks from northern Southeast Alaska (Area 3) are almost consistently larger (Table 9). Mass, however, can vary greatly according to season, prey abundance, and crop weight, so inferences based on this measure must be gauged cautiously (Whaley 1988). For male and female juvenile goshawks, examination of the mean and range of wing chord, tail, and mass measurements indicates a similar, but weaker trend of increase in size from south to north (wing chords in Table 8, tail and mass not shown).

2. *Comparison with Coastal B.C*

Table 8 and Figures 1 and 2 show that mean wing chords of both adult male and female goshawks from all Southeast Alaska areas (A = areas 1, 2, and 3 combined) were larger than mean wing chords reported for adult males and females from coastal British Columbia (*laingi)* specimens (Whaley 1988) (E). Comparison of the standard deviations of these means, however, shows a small overlap between wing chords of adult males from Southeast Alaska and coastal British Columbia (B.C.), and a large overlap between wing chords of adult females from these regions. Comparison of the wing chord ranges for juvenile males and females from Southeast Alaska and coastal B.C. (Table 8, A and E) also shows overlap.

Mean wing chords of adult male and female goshawks from Southeast Alaska Areas 1, 2, and 3 are given under letters B, C, and D, respectively, in Table 8 and Figures 1 and 2. Comparison of these values with mean wing chords reported from coastal B.C. goshawks (E) shows variation in the degree of overlap of the standard deviations. In Figure 1, the standard deviation for mean wing chord of adult male goshawks from coastal B. C. has a large overlap with that of southern Southeast Alaska Area 1 adult males (B), but little and no overlap with the middle and northern Areas 2 and 3, respectively (C and D). Wing chord was collected from only one adult female in Area 1. In Figure 2, this value (B) falls withing the standard deviation of coastal B.C adult females (E). Wing chord standard deviation for Area 2 (C)

adult females shows much overlap with that of coastal B.C. birds, while the standard deviation of the northern Southeast Alaska area 3 (D) adult females shows almost no overlap.

### 3. *Comparison with Other Regions*

Mean wing chords reported for adult goshawks from Alaska, excluding Southeast (I, Whaley 1988) are larger than those from Southeast Alaska (A, B, C, D) (Table 8, Figures 1 and 2). This observation indicates the latitudinal increase in mean wing chord northward from southern Southeast Alaska (noted above) appears to extend from Southeast Alaska to more northern latitudes in Alaska. This observation is consistent with Whaley's (1988) previously mentioned finding of a clinal increase in goshawk body size from the Pacific Northwest coasts of Washington and B.C. and Yukon Territory and Interior Alaska. Comparison of Southeast Alaska mean wing chords with data from Interior Alaska only (H, McGowan 1975), does not show this trend clearly. The large standard deviation reported for adult males from Interior Alaska indicated considerable variation in size.

Mean wing chords from Southeast Alaska as a group were similar to those reported for goshawks from mainland B.C. and Washington (F, Whaley 1988). However, when divided by south-north areas, mean wing chords of northern Southeast Alaska goshawks approach those of the latter group more closely than do goshawks from southern Southeast Alaska (Table 8, Figures 1 and 2). This may indicate that goshawks from northern Southeast Alaska are more similar in size to those from interior B.C. and Washington. Johnson (1989) found a significant difference in wing length (arc) and culmen length between the smaller insular (*laingi*) goshawks and the larger B.C. mainland goshawks in four of eight age-sex group comparisons. Though Beebe (1974) states that *laingi* "is a large goshawk, equalling the size of continental birds", Whaley (1988) has also demonstrated mensurally that the mainland B.C. goshawks are larger than their insular counterparts.

Rectrix lengths of adult goshawks of both sexes from Northeast Oregon and Southeast Alaska nest sites had similar means and ranges (Table 9). Mean mass, however, averaged and ranged larger for Southeast Alaska goshawks. Figures 1 and 2 show considerable overlap in the standard deviations of mean wing chords for adult males and females from these regions.

### 4. *Summary*

Our analyses and results were based on small sample sizes with no more than nine goshawks represented in any sex-age group. We also note that there are other sources of error to be considered in comparative analyses of morphometric data. For example, most morphometric data presented for goshawks in the literature --and much of the data we used for comparative purposes-- was taken from museum specimens, which are known to dry and shrink with time (Kemp 1987; Fjeldsa 1980 and Henny and Clark 1982 *in*: Henny et al 1985; Smith 1988 *in*: Whaley 1980). Because all Southeast Alaska morphometric data was collected from live goshawks, these wing chords and other measurements are probably some degree larger than

those that would be collected from study skins prepared from the same individuals. In Table 8 and Figures 1 and 2, mean wing chords from Southeast Alaska (A, B, C, D), Interior Alaska (H), and Northeast Oregon (I) were taken from live specimens; all others (E, F, G, J, K) were taken from museum specimens.

Possible measurement error should also be considered. Though all measurements were carefully taken by the same researchers in both this study and the other studies cited, errors in measurement may become significant when the observed variation among individuals is relatively small (Table 8, Figures 1 and 2).

In summary, preliminary analysis of morphometric data shows that mean wing chords for adult male and female goshawks from Southeast Alaska approach and overlap those reported by Whaley (1988) for *laingi* goshawks from coastal B.C. Within Southeast Alaska, there may be a gradient in goshawk size, with slightly larger individuals occurring in the north and smaller individuals in the south. This trend was most apparent in comparisons of mean wing chord. Mean and range of tail length and mass for adult male and female goshawks show a similar but weaker trend. The smaller wing chords observed for southern Southeast Alaska goshawks more closely approach wing chords reported for *laingi* goshawks from coastal B.C. than do mean wing chords of northern Southeast Alaska goshawks.

Mean wing chords from Southeast Alaska goshawks were smaller than those reported for goshawks from Alaska excluding Southeast. This observation was consistent with the reported clinal increase in goshawk size between coastal Pacific Northwest and more northern latitudes of Alaska (Whaley 1988). Mean wing chords of Southeast Alaska goshawks as a group were considerably smaller than those of *A.g. apache* of the Southwest, but similar to those reported for Northeast Oregon and the eastern U.S.

B. Plumage

Taverner (1940) examined 53 adult and 62 juvenile goshawk museum skins from across North America (primarily Canada) and noted a degree of plumage darkening in individuals from islands of the British Columbia coast. Among adults, darkening was variable but distinct in the 4 specimens from the Queen Charlotte Island and the 9 specimens from Vancouver and Denman Islands. Among juveniles, all 5 specimens from the Queen Charlotte Islands exhibited distinct darkening, while the 19 specimens from Vancouver Island showed lesser, more variable darkening. The group of cross-continental mainland adult goshawks examined by Taverner showed "no consistent departures" from the lighter *atricapillus* types.

Based on these observations, Taverner (1940) defined the Queen Charlotte goshawk, *(A.g.) laingi*, as:

*Diagnosis:* Like (*atricapillus*), but faintly to distinctly darker especially in first and second year. Adult, sootier gray ventrally especially across breast, typically with many broad shaft streaks. Dorsally with the black cap and

nape extending over shoulders and the interscapulars. Juvenile, breast stripes very broad and heavy on a light ground that averages deeper in color than in *atricapillus*. Dorsally almost or quite solid rich dark brown with little or no light feather-edging or semi-concealed markings.

*Range:* As far as known, the islands of the British Columbian coast. Most typical on the Queen Charlotte Islands, the birds of Vancouver Island being more variable and less plainly characterized. Probably resident, with little migratory movement.

The American Ornithologists' Union adopted Taverner's classification in 1957 (A.O.U. 1957).

In his treatise on the Falconiformes of British Columbia, Beebe (1974) states:

*A.g. laingi* is the goshawk of the north coastal islands of British Columbia, southeastern Alaska (Alexander Archipelago), and the Queen Charlotte Islands... Mature adults of this race have the black of the head extending to nearly the mid-point of the back before lightening to a dark, leaden grey. The close barring of the underside is darker and coarser than that of continental birds, with the shaftline marks wider and black, not grey. Immatures are similarly much darker, the only real white anywhere being the eyebrow line, nape feathers, and the undertail plumes...

Beebe also describes the plumage features of the mainland *A.g. atricapillus*:

*Adult*: Crown and entire top of head black... Dorsally, from nape to tail, including the wings, uniform pale slate or bluish-grey... Males are slightly paler and bluer... than females... Ventrally the ground color is white, but all feathers are so closely and delicately barred with grey that the ground color is obscured, resulting in a uniform pale-grey appearance, lighter than the dorsal grey but with no hint of blue...

*Immatures (first year)*: ... Dorsal surface, pale brown, all feathers darker brown subterminally, with rather wide, light-brown edges and tips, making the entire dorsal surface look barred. Underparts pale tawny to white, streaked with dark brown... Tail, pale brown above, grey below...

We examined and photographed the plumage of 34 goshawks, including 17 adults and 17 juveniles, captured at Southeast Alaska nest sites. Color photo records and field notes were used to compare the degree of similarity between the observed plumage of each Southeast Alaska goshawk and plumage descriptions given for *laingi* and *atricapillus* in the literature. Though the methodology in this process is inherently subjective and in some cases requires distinguishing subtle characters, the intent of this exercise was to systematically compare the plumages of adult and juvenile goshawks from Southeast Alaska with the known *laingi* and *atricapillus* descriptions (see below, c. Discussion).

Taverner (1940) indicates an intergradation occurs between the darker plumage extreme of *laingi* and the lighter plumage extreme of *atricapillus*, with some individuals exhibiting plumage features that cannot be distinguished as distinctly one type or the other. This observation is consistent with the plumage variations occurring in clines (Proctor and Lynch 1993). To characterize goshawks from Southeast Alaska, each individual's plumage was

described on a scale ranging between the *laingi* and *atricapillus* extremes. For each of three plumage distinctions (A, B, and C) taken from Taverner's and Beebe's plumage descriptions (above), adults and juveniles were scored on a whole number scale from "0" to "10", with "10" indicating complete similarity to the darkest extreme of the *laingi* description, and "0" indicating complete similarity to the lightest extreme of the *atricapillus* description (see Tables 10A and B).

As with the morphometric data (above), each goshawk was placed in one of three south to north divisions (Areas 1, 2, and 3) of Southeast Alaska -- depending on the location of the nest site where it was captured, to examine possible latitudinal variation in plumage. Total score possibilities for each goshawk and Area mean score were from "30", indicating the darkest extreme of *laingi* description, and "0", indicating the lightest extreme of the *atricapillus* description (see Tables 10A and B).

1. *Adults*

The plumage scores for Southeast Alaska adult goshawks shown in Table 10A reflect the observation that the compared plumage distinctions varied among individuals, but generally averaged and ranged more closely to the description of the *laingi* extreme than the *atricapillus* extreme. No observable difference in plumage was noted between grouped adults from Areas 1, 2, and 3. Plumage variation in adults ranged from overall dark individuals which match the description of the darkest *laingi* type (e.g., Area 2, Big John Creek female; Area 2, Rowan Creek female), to lighter individuals that might be identified as either light *laingi* or dark *atricapillus* (e.g., Area 3, Point Bridget female; Area 3, Ready Bullion female).

Among adults, considerable variation was observed in the scores for plumage distinction A, dorsal coloration (Table 10A). Literal interpretation of both Taverner's and Beebe's definitions for *laingi* adults describes the black of the crown and nape extending posteriorly over the shoulders and interscapulars. In most Southeast Alaska adults, a slight to distinct progressive lightening of this black was observed extending from the feathers posterior of the nape to the interscapulars. No individual was scored "10" (black to black transition) for this distinction. Among individuals, the nape to mid-back transition ranged from black to blackish-grey, to black to medium grey. The uniform pale slate grey describing the lightest *atricapillus* individuals posterior of the nape was not observed distinctly in any individual, though darker variation of this color —which might fit the range of coloration for either subspecies-- was observed in a number of individuals. Overall, the dorsal coloration of Southeast Alaska adults generally ranged from medium grey to dark blackish-grey.

Ventrally, Southeast Alaska adults ranged from individuals with coarse, sooty-grey cross barring the breast and wings, densely marked with broad, black shaft streaks (e.g., Area 3, Big John Creek, female; Area 3, Rowan Creek, female), to others with fine, sooty-tinted grey cross barring, lightly marked with thin black shaft streaks (e.g., Area 1, Sarkar Lake, male; Area 3, Blueberry Hill, male) (Table 10A, plumage distinction B). The difference between

these latter individuals and the pale-grey appearance describing *atricapillus* individuals ventrally was not great. However, in all Southeast Alaska adults some degree of sooty tinting was observed, especially on the breast. As with the coloration of dorsal plumage (distinction A), the ventral coloration and streaking observed in most adults placed them in the wide integradation between the plumages descriptions reported for the two subspecies, but scores for this distinction also averaged closer to the *laingi* extreme than the *atricapillus* extreme. Consistent with Clark and Wheeler's (1987) description for northern goshawks, Southeast Alaska adult females were generally observed to have coarser and darker ventral barring with more vertical streaking than adult males.

Taverner's original description of *laingi* (above) states that individuals of this subspecies are faintly to distinctly darker than *(atricapillus)*, especially in the first and second year (juvenile plumage and the first adult plumage). The plumage of two Southeast Alaska adult goshawks was distinctly darker overall and more heavily barred and streaked ventrally than that of all other individuals in the sample. These two were the Big John Creek female (Area 2) and the Rowan Creek female (Area 2) (Table 10A). Consistent with Taverner's description, we observed that these two adult females could be identified with a high degree of confidence as two or three year-old individuals by a very light orange eye color (Big John Creek), and the presence of remanent juvenile (brown) dorsal plumage and remanent second year adult ventral plumage (Rowan Creek) (Beebe 1974).

Though not in Taverner's (1940) original description, Beebe (1974) adds that the ventral feathers of adult *laingi* have thick black shaft streaks, while those of *atricapillus* are thinner and grey. Scoring for this distinction (Table 10A, plumage distinction C) reflected both the relative proportion of black-shafted feathers to greyish or greyish-brown-shafted feathers ventrally, and also the relative thickness and overall density of vertical streaking on the breast. Black-shafted feathers were observed ventrally in all individuals, though the proportion of these feathers and the thickness of feather shaft streaks were variable among individuals.

The observed range for this plumage distinction was from individuals that were densely streaked with thick, black shaft marks on almost the entire ventral surface (Area 2, Big John Creek, female; Area 2, Rowan Creek, female), to others that had thin black shaft streaks limited to the breast or breast and anterior wing, and greyish or greyish-brown shafts in other ventral body feathers (e.g., Area 3, Point Bridget, female; Area 3, Nugget Creek, male). Taverner (1940) notes that the degree of vermiculation of the breast and ventral plumage pattern in goshawks is age related, with older individuals being more finely streaked. As noted above, the two adults that were observed to have the greatest proportion of thick feather shaft streaking ventrally, are known to be only two or three years old. As with distinction B (ventral barring, above) and also consistent with Clark and Wheeler (1987), adult females generally had thicker and denser vertical shaft streaking ventrally than adult males.

2. *Juveniles*

Plumage scores for the Southeast Alaska juvenile goshawks reflect the observation that in addition to much variation among individuals, the plumage of juveniles as a group could not be described as distinctly of the *laingi*-type or the *atricapillus*-type. Plumage variation ranged from overall dark individuals that closely approached the *laingi* extreme, to lighter individuals that more closely approached the *atricapillus* extreme. Total scores for juveniles show that while some individuals could be described as more typically *laingi*, the majority fell into the intergradation describing both light *laingi* and dark *atricapillus* individuals. As with adults, no observable difference in plumage was observed between grouped juveniles from Areas 1, 2, and 3 (Table 10B).

Among juveniles, the greatest similarity to the *laingi* description was found in plumage distinction A, dorsal plumage base coloration (Table 10B). All juveniles were observed to have dorsal plumage ranging from mostly or completely dark brown to medium brown. No juvenile had exclusively the pale brown dorsal base color used to describe the *atricapillus* extreme.

Plumage distinction B, the degree of dorsal feather light edging, was more variable (Table 10B). This distinction ranged from juveniles with dorsal feathers having no edging or a thin rust-colored edging, to others with nearly all dorsal feathers having wide tawny-colored edging or semi-concealed spots. All juveniles were observed to have at least some dorsal feathers with lighter terminal edges.

Plumage distinction C, ventral base color and degree of ventral streaking, ranged from individuals having a rich cinnamon-buff colored breast densely streaked with wide, dark brown markings (e.g., Area 2, Falls Creek, male), to others having a tawny-white ventral base color moderately streaked with thinner medium brown markings (e.g., Area 3, Eagle Creek males -41967 and -41968) (Table 10B). All juveniles were observed to have moderate to dense dark brown streaking on the breast, but ventral base color was more variable and in many individuals was more similar to the *atricapillus* extreme.

C. Discussion

As noted above, the methodology used in visually comparing plumages of Southeast Alaska goshawks to literature descriptions for the *laingi* and *atricapillus* subspecies contains a considerable degree of subjectivity. Additionally, error and inconsistency in scoring is added with variation in field notes, photo lighting, photo exposure, camera angle, and even film type. Ideally, this kind of plumage inspection would be done using *laingi* and *atricapillus* type specimens in the field for comparison with live-trapped goshawks; however, this was not practical.

The purpose of these comparisons was to examine and describe individual plumages on a

relative scale of known types, as part of efforts to elucidate the systematic and taxonomic description of Southeast Alaska goshawks. As Wiley (1980 *in* Kemp 1987) notes: systematics is based on comparison of as many characters for as many organisms as possible. Characters include any attribute or observable part of an organism that can be described, illustrated, measured, weighed, counted, scored, or otherwise communicated by one biologist to another.

Results of the plumage comparisons show that adult and juvenile goshawks from Southeast Alaska ranged from individuals that completely or almost completely met descriptions for the darkest extreme of *laingi* plumage, to others whose overall features placed them within the wide intergradation between the *laingi* and *atricapillus* descriptions. Plumage distinctions that could be described as clearly typical of the lighter *atricapillus* extreme were observed only in some juveniles.

Taverner (1940) described similar variation among specimens of both age groups he examined. Among adults, he noted distinct but variable plumage darkening in all specimens from the Queen Charlotte Island and Vancouver Island. Among juveniles, darkening was distinct and consistent in all specimens from the Queen Charlotte Islands, but lesser and more variable among those from Vancouver Island. He further described the juvenile group from Vancouver Island as an intergradation between the *laingi* type and the *atricapillus* type, with individuals characterized by plumage that might be included in either group.

Webster (1988) compared seven adults specimens from Southeast Alaska with a series of specimens from other regions. Two of the Southeast Alaska specimens he described as *atricapillus*. The other five he described as not as dark as those from the Queen Charlotte Islands, but just as dark as those from Vancouver Island. These latter individuals he considered to be *laingi*.

Similar to Webster's observation, we observed that Southeast Alaska adult goshawks as a group were not as dark as the darkest individuals described by Taverner, though a few individuals were equally as dark and most are probably within the variation he indicates. Considering all plumage distinctions, the adult Southeast Alaska goshawks observed in the current study are best described as having slightly to very darkened plumage, with the majority falling into the wide intergradation between the *laingi* and *atricapillus* plumage descriptions. The lightest individuals could be described as darker variants of *atricapillus*.

Consistent with Taverner's description of juvenile goshawks on Vancouver Island, we found the plumage of juvenile goshawks in Southeast Alaska to be variable and not as distinctly dark as his description of the five juveniles from the Queen Charlotte Islands. Though some Southeast Alaska juveniles closely approached this description, many showed some *atricapillus*-like features which, as with adults, placed them in the intergradation between the *laingi* and *atricapillus* types. Swarth (1911) also describes both very dark and light-colored immature goshawk specimens that were collected in Southeast Alaska in late summer.

Taverner's sample of juvenile goshawks from the Queen Charlotte Islands included only five

individuals. However, the lack of lighter variants in this sample and the high proportion of lighter *atricapillus*-like variants observed both by Taverner on Vancouver Island and by this study in Southeast Alaska, may suggest that a gradient of phenotype exists, with the darkest individuals occurring in the region of the Queen Charlotte Islands and lighter individuals occurring south and north of here. This observation may also be suggested for adults, at least in a northward direction to Southeast Alaska, both by Wester's (1988) observation of "not quite as black" and "*atricapillus*" adults from this region, and by the large proportion of adult phenotypes observed in the current study which fell into the intergradation between the *laingi* and *atricapillus* descriptions. Possibly, the apparent occurrence of consistently dark adult and juvenile goshawks on the Queen Charlotte Islands may be due, in part, to the much greater open water separation between the mainland and these islands (minimum of 75 km/47 mi), which has allowed less immigration of lighter *atricapillus* individuals from the mainland than on Vancouver Island and in Southeast Alaska.

The plumage and range of *laingi* were first described by Taverner (1940) more than fifty years ago based on his comparative examination of thirty-five atypically dark-feathered goshawk study skins from the coastal islands of British Columbia. Since his original description, only a few individuals have commented further on the physical attributes of this goshawk race. Beebe (1974) confirmed Taverner's phenotypic description and Webster (1988) extended the northern range after observing similar phenotype in specimens from Southeast Alaska. Whaley (1988) mensurally examined goshawk specimens from the islands of coastal B.C. and found them to average smaller in size than goshawks from other regions of North America. However, even though Taverner's original description of *laingi* mentions considerable plumage variation among individuals, no work has been done to accurately describe the biogeography of this goshawk race or the degree and extent of its apparent intergradation with *atricapillus*. With the exception of preliminary findings from the current ADF&G-USFS study, little is known of its ecology.

Local environmental conditions directly affect the morphology of birds and play a long-term role in creating geographic subspecies (Proctor and Lynch 1993). The dark coloration and small size of goshawks inhabiting coastal B.C. and Southeast Alaska are thought to be adaptations to the wet maritime climate and temperate rainforests. Dark plumage is probably a reflection of the colors of vegetation, which tend to be dark and lush in humid environments (Gloger's Rule, Proctor and Lynch 1993), and may add a degree of camouflage to predators such as the goshawk. The relatively smaller size of goshawks from this region may be an adaptation for flying through dense rainforest vegetation. The greater agility given to goshawks with these smaller dimensions may also be a reflection of their diet, a large part of which is known to consist of forest passerines such as the Steller's jay and the varied thrush (Whaley 1988).

Wiley (1981 *in*: Kemp 1987) states: "Taxonomy comprises the theory and practice of describing the diversity of organisms and ordering this diversity into a system of words that conveys information concerning the kind of relationship between organisms that the investigator thinks is relevant". This definition reminds us that taxonomic classification is

often based on a simplified interpretation of what we perceive a species' role to be within ecosystems that are both complex and often not well understood. The decision to taxonomically classify organisms at the level subspecies is largely an arbitrary one if based soley on comparison of subtle physical characters.

Distinctions that have been used to describe the morphology and range of *laingi* subspecies are a reflection of adaptations to the habitats and environmental conditions of the Pacific Northwest coastal temperate rainforests. Patterns of variability are subtle within N.A. goshawks but some clinal patterns can be found. That goshawks in Southeast Alaska exhibit slight physical variation compared with other regions indicates that they are adapted to these conditions in many aspects of their natural history.

## 6. Status of Genetic Analysis of Blood Samples

ADF&G biologists collected blood samples from 35 goshawks in Southeast Alaska between November 1991 and August 1993 (Table 11). Samples were sent to Drs. Thomas A. Gavin and Bernie May of Cornell University who, in collaboration with Dr. Richard T. Reynolds, USDA Forest Service, are analyzing goshawk DNA to examine genetic variation and taxonomy of *Accipiter gentilis* in North America. This research will assess the genetic basis of current subspecific variation in the northern goshawk. When combined with information gathered through continued collection of morphological data the results should provide useful insight into the geographical distribution of *A.g. laingi* in Southeast Alaska. A final report discussing the results of DNA analysis is expected by September, 1994.

## 7. Home range and habitat associations based on radio-telemetry

### A. Introduction

Major objectives were to determine home range sizes and habitat associations of goshawks on the Tongass National Forest. The relationships between habitat associations of goshawks at the landscape level remain unknown in the Pacific Northwest and Southeast Alaska. This is in contrast to studies of northern spotted owl (*Strix occidentalis*) habitat associations as related to home range and landscapes (e.g., Gutiérrez and Carey 1985, Lehmkuhl and Raphael 1993) that are well understood. Goshawk habitat associations and home ranges have been studied in northern Europe (e.g., Kenward 1982, Widén 1989) along with some U.S. studies (e.g., Kennedy 1989). Ecologists are beginning to recognize the importance of the entire landscape in habitat management planning to insure long-term viability (Reynolds et al. 1992). Yet, an understanding of the general patterns of goshawk use of their home range and the landscape habitats available to them are lacking in the Pacific Northwest and Southeast Alaska. Our objectives in assessing goshawk home ranges and habitat association patterns to forest management in terms of testing for environmental impacts (e.g., Stewart-Oaten et al. 1992, Underwood 1994) and using the information in forest planning (e.g., Walters and Holling 1990, Irwin and Wigley 1993). Our goshawk studies remain descriptive because of

sampling problems that preclude post-hoc hypothesis testing of landscape patterns (e.g., home range size in clearcut versus no-cut landscapes) at the current time.

## B. Methods

### 1. *Field Methods*

We used standard radio-telemetry methods for determining goshawk habitat associations and home ranges (ADF&G 1993*d*, Litvaitis et al. 1994, Samuel and Fuller 1994). Active goshawk nests were located using a variety of methods including searching historic nesting areas, random searching and playing of conspecific calls, timber sale preparation goshawk inventories, and reports from the public (ADF&G 1993*b,c*). Most adult goshawks were trapped at their nest sites with the use of a live great horned owl (*Bubo virginianus*) as a lure (Bloom et al. 1992). Juvenile goshawks were trapped post-fledgling near their nest sites using bal-chatri traps (Bloom 1987). Back-pack or tail-mount radio-transmitters were affixed to adult goshawks depending on capture date and stage of molt. All juvenile goshawks received tail-mount transmitters.

Fixed-wing aircraft were used to determine goshawk locations. Ground-based telemetry was not used owing to the paucity of roads and the mountainous terrain. The frequency of relocations varied depending on weather, aircraft availability and financial resources. At the time of individual aerial relocations, observers estimated goshawk locations on 1:63,360 topographic maps, aerial photographs or ortho-photo quadrangles when available. Observers also estimated the habitat type at each goshawk relocation point along with the timber volume class.

During aerial tracking flights the observer visually estimated forest volume class at each goshawk relocation point. Relocations were assigned to one of five volume class categories for analysis: NCFL = noncommercial forest land, V.C. 3 = 0 to 8 MBF/acre, V.C. 4 = 8 to 20 MBF/acre, V.C. 5 = 20 to 30 MBF/acre, V.C. 6+7 = > 30 MBF/acre. In the relatively few instances where observer estimates of volume class were not documented during aerial tracking flights, volume class was estimated using aerial photographs. Estimates of volume class at relocation points were pooled for all goshawks and then analyzed to determine the frequency of relocation occurrence within each volume class category.

### 2. *Data Management and Analysis*

All relocations collected between June 17, 1992 and November 7, 1993 were digitized, proofed for accurate placement, and assigned a state plane coordinate. We used the Tongass National Forest's Geographic Information System (GIS) for data entry. GIS efforts were led by E. J. DeGayner. Check maps were produced from the digitized data and extensive proofing and editing occurred to resolve plotting errors. Data were then transferred to a

We pooled all independent relocations to examine total home range size. Total home range sizes increased with the inclusion of post-breeding season relocations (Tables 13 and 15). There was also substantial variation in total home range sizes with a coefficient of variation in mean home range size of 147%. Median MCP total home ranges sizes were nearly equal for males and females (5843 ha ♂♂; 5942 ha ♀♀). Two patterns were apparent when examining the home range data from GIS maps (Appendix I) and the harmonic mean plots (Appendices II and III). One pattern, particularly for males, was a loose association with the breeding season home range that expanded somewhat during the non-breeding period (e.g., birds BBF1, ECF1, Appendices I and III). The other pattern that only occurred for some females, was a post-nesting range spatially separated from the breeding season home range. Examples of this pattern included birds SLF1 and BJF1). Subsequent telemetry data through May 1994 indicated that adult female goshawk PBF1 subsequently renested where she spent the winter apart from her previous breeding range. These patterns of some adult goshawks remaining resident within one locale while others establish a subsequent home range up to 56 km from where they previously nested presents conceptual problems for our home range analyses.

We found a pattern of increasing home range size with an increase in sample size (Figures 3,4,5 and 6; White and Garrott 1990). This relationship was confounded by additional ecological patterns that might not be solely attributable to correlates with sample size. For example, the largest breeding season home ranges were all from the Stikine and Ketchikan areas of the Tongass National Forest. This pattern held whether home range size was calculated using MCP or HM methods (Figures 3 and 4). The smallest estimated home ranges were found on the Chatham Area where we had the fewest relocation samples. There are two methods to understand the pattern of varying home range sizes and varying relocation sample sizes. First, more data from additional adults can be collected to determine if the pattern is general. Second, a randomization routine can be developed by subsampling the larger samples to determine the probability that larger home ranges occurred in central and southern Southeast Alaska.

The 90% HM home range sizes we estimated were larger than those found by Kennedy (1989) from New Mexico, although our dates, methods, and estimators were not directly comparable. Widén (1989) had winter MCP home ranges averaging 8,700 ha ($n$ = 14) with great individual variation in home range size. His season of intensive monitoring differed from ours.

### D. Habitat Associations

Of the total 676 independent relocation points collected from radio-tagged goshawks 667 were analyzed to determine the frequency of occurrence within specific habitat types. Nine relocations which could not be confidently assigned to a specific habitat type were excluded from this analysis. When radio-tagged goshawks were examined as a group (all ages/sexes combined) the highest percentage of relocations occurred in old growth forest (90%) including; conifer (69%), beach fringe <100 meters from the beach (8%), riparian (8%), and

mixed conifer (5%)(Figure 7). Only 5% of relocations occurred in previously harvested stands including mature second growth (4%), and recent clearcuts or young second growth < 20 years of age (1%). Only 6% of all relocations were in unforested habitat or non-commercial forests less than 8,000 board feet per acre. No measurable differences in habitat use were observed when goshawk relocations were examined by age or sex. Sixty-nine percent of 349 female relocations were estimated to be in old-growth coniferous forest and 69% of 312 male relocations were estimated to be in old-growth coniferous forest.

### E. Volume Class Use

The frequency of relocations occurrence by volume class based on observer estimates was calculated using 661 of the 676 total independent relocations. A total of 15 relocations which could not be confidently assigned to a specific volume class were excluded from this sample. When relocations were distributed for all goshawks by observer estimated volume class, the greatest frequency of relocations occurred in volume classes 5 (57%), 4 (24%) and 6 (11%). Only 1% of relocations were in noncommercial forests or unforested habitat (Figure 7). Patterns in the percentage of volume classes used by the sexes or age combinations did indicated consistency. For example, 61% of 349 relocations from female goshawks were in volume class 5, whereas 52% of 312 relocations from male goshawks were in volume class 5.

Estimating timber volume class from an airplane is subject to a number of possible errors that require additional assessments prior to comparing these results with GIS volume class estimates for the forest as a whole. For example, volume class was recorded by differing individuals under varying field conditions with unknown error. Despite the subjectivity in this estimator, there was a high frequency of goshawk relocations associated with forests of a minimum tree height and old-growth forest pattern. Alternative methods for estimating timber volume, such as the use of aerial photographs may be useful (e.g., Setzer and Mead 1988). Yet, given the large goshawk home ranges we have measured, estimating timber volumes with any labor intensive efforts may not be feasible for our study alone.

## 8. Juvenile Fledging, Dispersal, and Survival

The age of nestling and fledgling goshawks was estimated by comparing observed physical development with age-specific characters given by McGowan (1975). Kenward, et al. (1993) noted that goshawks generally fledge at 35 to 42 days after hatching, with males fledging first. Johnsgard (1990) reports that goshawks fledging typically occurs at 35 to 36 days for males and 40 to 42 days for females. Date of fledging for Southeast Alaska juveniles was estimated using fledging ages of 36 and 42 days for males and females, respectively.

Mean estimated fledging date of 14 Southeast Alaska juvenile goshawks at nine nest sites was July 16, ranging from June 29 to July 27 (Table 16). The earliest fledging was at the Sarkar Lake nest on Prince of Wales Island in the Ketchikan Area in 1992, while the latest fledging

was at the Big John Creek nest on Kupreanof Island in the Stikine Area in 1993. No pattern was noted between the estimated fledging dates of juveniles from nests at northern and southern latitudes within Southeast Alaska.

Juvenile goshawks were considered to have dispersed from their nest sites when they ventured > 1.5 km (0.9 mi) from the nest (Kenward, et al. 1993). Dispersal dates of Southeast Alaska radio-tagged juveniles were estimated by averaging the date of the first relocation greater than 1.5 km from the nest with the date of the last relocation within this distance of the nest. Mean dispersal date of fourteen Southeast Alaska juvenile goshawks was August 24, ranging from August 5 to September 5 (Table 16).

Mean estimated post-fledging period --the duration between fledging and dispersal-- for all juveniles was 40 days, with a range of 35 to 47 days (Table 16). No difference was observed in the mean post-fledging period of males and females. Adding the mean 40 day post-fledging period to fledging ages of 36 and 42 days for males and females, gives an estimated dispersal age range of 76 to 82 days for Southeast Alaska juveniles. This is consistent with the 70 to 80 day age range of juvenile independence reported by Johnsgard (1990). Kenward et al. (1993) observed that 90% of 221 radio-tagged juvenile goshawks (*A.g. gentilis*) dispersed at 65 to 90 days. They concluded that dispersal was enabled by completion of feather growth and was accelerated by food shortage, but probably resulted from behavior maturation when food was abundant. They also found that juvenile females were found to disperse significantly later than juvenile males in all areas. For Southeast Alaska juveniles, mean estimated dispersal age was 82 days for seven females and 75 days for seven males (Table 16).

Dispersal of radio-tagged juvenile goshawks was monitored by aerial tracking. Tracking efforts varied both between 1992 and 1993, and the between Ketchikan, Stikine, and Chatham Areas of the Tongass National Forest. Weather and the availability of funding for aircraft charter most often dictated the timing and frequency of tracking flights.

Three of 14 (21%) juveniles from 1992 and 1993 could not be relocated after dispersal (Table 16; SLM2, SLM3, ECM2). For these three males, it could not be determined if transmitters failed or if early large scale movements prevented relocation. A total of four (29%) juveniles could not be relocated after mid-October. These included two males (PBM2, ECM3) that were last relocated on August 27, and two females (BBF2, NCF2) that were last relocated on October 11. The status of these individuals also could not be determined. The seven (50%) remaining juveniles included two males (LJM2, PBM3) and five females (BJF2, RNF2, RNF3, BBF2, NCF3). These individuals were monitored through early January, 1994. One female and one male (14%), however, were subsequently located as mortalities. These included Chatham Area RBF2, ~January 1993, and Chatham Area PBM3 on April 13, 1994. The tail feather-transmitter package of Stikine Area RNF3 was recovered on January 25, 1994 and is presumed to have been pulled out by this goshawk while alive.

Maximum dispersal distance of each Southeast Alaska juvenile was calculated on the Forest

Service's GIS as a straight line between the nest and the most distant relocation recorded between August and January (Table 16). For eleven juveniles, including five males and seven females, the mean maximum distance recorded through November 7 was 64.5 km (40.3 mi), with a range of 15.9 km (9.9 mi) to 151.1 km (94.4 mi). These numbers reflect both the great mobility and variation in movements of dispersing juveniles in Southeast Alaska.

As noted above, 50% of the original fourteen juvenile goshawks could not be relocated after mid-Ocotober. Though transmitter failure may have occurred with some of these individuals, it is also likely that large scale movements beyond the range of tracking occurred with others. The actual mean and range of maximum dispersal distance for all individuals is was probably greater than that recorded. Relocation of half of the radio-tagged juveniles between August and early January indicated that at least this portion were non-migratory, and also that fledgling survival to mid-winter was at least 50%.

## 9. Summary of Radio-telemetry Monitoring - through May 1994

### A. Ketchikan Area

In 1992, a total of four goshawks, including two adults and two juveniles, were radio-tagged at one nest site at Sarkar Lake on Prince of Wales Island. Neither juvenile could be relocated after dispersing from the nest site. The adult male was found dead on March 10, 1993 on Kosciusko Island. The adult female did not nest in 1993 but was found to be nesting on Heceta Island on 16 May 1994 and is currently being monitored.

In 1993 two goshawks, an adult male and juvenile male, were radio-tagged at one nest site at Logjam Creek on Prince of Wales Island. The adult male was found dead on November 3, 1993. The carcass was sent to the Washington Animal Disease Diagnostic Laboratory at Washington State University for necropsy. Results of a gross diagnosis indicate the cause of death was starvation, however, its etiology could not be determined. The juvenile male from this site dispersed northward to Kupreanof Island and is currently being monitored by USFS Petersburg Ranger District biologists.

### B. Stikine Area

No goshawks were radio-tagged in the Stikine Area during 1992. In 1993 a total of nine goshawks were captured and radio-tagged, including four adults and four juveniles at two nest sites (Big John Creek nest site on Kupreanof Island and the Rowan Creek nest site on Kuiu Island). One additional adult male of unknown origin was captured and radio-tagged in Petersburg on Mitkof Island on 27 December 1993.

Of the nine goshawks originally radio-tagged in the Stikine Area during 1993 five, including four adults and one juvenile, were still being monitored as of May 1994. The adult male

from the Big John nest site has not been relocated since 23 March 1994 and transmitter failure is suspected. Of the four juveniles originally radio-tagged one was found dead on 19 August 1993 during the fledgling dependency period, one dropped its tail-mounted radio package which was recovered on 25 January 1994 and another has died or dropped its radio-transmitter package. In addition to the goshawks originally radio-tagged in the Stikine area, USFS Petersburg Ranger District biologists are currently monitoring one juvenile male which fledged from the Logjam Creek nest site on Prince of Wales Island in the Ketchikan Area and dispersed northward to Kupreanof Island.

C. Chatham Area

In 1992 a total of three goshawks, including two adults and one juvenile, were radio-tagged at the Ready Bullion Creek nest site on Douglas Island. The adult male at this site could not be relocated after September 23, 1992 and his status is unknown. Repeated winter relocations for the adult female were made at a high elevation on Douglas Island. Though the transmitter failed before it could be recovered, it is suspected that this bird died. The juvenile female fledged from this site was found dead (~9 miles) from the nest on 26 March 1993.

A total of fifteen goshawks, including eight adults and seven juveniles, were captured and radio-tagged at four nest sites in the Juneau area in 1993. These include the Blueberry Hill, Nugget Creek, Point Bridget, and Eagle Creek sites. Additionally, a juvenile male was captured and radio-tagged at Sunny Point near Juneau on 30 December 1993. Of the total sixteen goshawks radio-tagged in 1993, nine were still being monitored as of 18 May 1994, including six adults and two juveniles. Transmitter failure is suspected in the case of the two missing adults. Of the eight juveniles originally radio-tagged, two are currently being monitored. One was juvenile was found dead (22 mi.) from the nest on (13 April 1994), and five others cannot be relocated.

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Table 1. Summary of documented northern goshawk nesting activity in Southeast Alaska.

Ketchikan Area

| Nest Site | Site Located | Site Checked | Active Nest | # Nests Located | Comments |
|---|---|---|---|---|---|
| Port Refugio, Suemez Island | 1989 | 1990, 1991, 1992, 1993 | 1989 | 3 | adult goshawks present 1992, 1993 |
| Sarheen, POWI | 1991 | 1991, 1992, 1993 | not located | 1 | adults & fledglings present, 1991; adults, 1992, 1993 |
| Sarkar Lake, POWI | 1992 | 1992, 1993 | 1992 | 1 | adult male & female, and 2 male fledglings radio-tagged 1992. Adult male found dead 3/92 |
| Logjam Creek, POWI | 1993 | 1993 | 1993 | 1 | adult male and fledgling male radio-tagged 1993 |

Stikine Area

| Nest Site | Site Located | Site Checked | Active Nest | # Nests Located | Comments |
|---|---|---|---|---|---|
| Cabin Creek, Mitkof Island | 1982 | 1992, 1993 | not located | 0 | Aggressive adult present in nesting season. Nest not located. Stand cut. |
| Mossman Inlet, Etolin Island | 1986 | 1986, 1992, 1993 | 1986 | 1 | 2 fledglings 1986 |
| Kake, Kupreanof Island | 1989 | 1990 | 1989 | 1 | Nest tree cut 1989; 2 nestlings |
| Pan Creek, Mitkof Island | 1990 | 1990-1993 | not located | 0 | adult goshawk 4/4/90; fledgling 7/23/90; goshawk 4/29/92 |
| Starfish, Etolin Island | 1991 | 1991, 1992, 1993 | 1991 | 1 | 3 young fledged 1991 |
| Falls Creek, Mitkof Island | 1992 | 1992, 1993 | not located | 0 | 1 fledgling male caught & banded 8/4/92; adult feather found. |

| | | | | | |
|---|---|---|---|---|---|
| Big John Creek, Kupreanof Island | 1992 | 1992, 1993 | 1992, 1993 | 3 | 2 female fledglings banded 1992; adult male & female & nestling male & female radio-tagged 1993 |
| Rowan Bay, Kuiu Island | 1993 | 1993 | 1993 | 1 | adult male and female & fledgling male & female radio-tagged 1993 |
| Upper Totem Creek, Kupreanof Island | 1993 | 1993 | not located | 2 | two inactive nest located in 1993; old prey remains and adult feather |

**Table 1. (cont.)**

**Chatham Area**

| Nest Site | Site Located | Site Checked | Active Nest | # Nests Located | Comments |
|---|---|---|---|---|---|
| Dewey Lake Trail, Skagway | 1985 | 1985 | 1985, 1987(?) | 1 | Pair of aggressive adults 1985, 1987(?); nest located |
| Thayer Lake, Admiralty Island | 1986 | 1986-1988 | not located | 0 | pair of aggressive adults 1986-1988; prey remains |
| Ready Bullion Crk., Douglas Island | 1991 | 1991-1993 | 1991, 1992 | 2 | adult male & female and fledgling female radio-tagged 1992 |
| Point Bridget, Echo Cove | 1992 | 1992, 1993 | 1992, 1993 | 3 | adult male & female and 2 fledgling males radio-tagged 1993 |
| Blueberry Hill, Douglas Island | 1993 | 1993 | 1993 | 1 | adult male & female and fledgling female radio-tagged 1993 |
| Eagle Creek, Douglas Island | 1993 | 1993 | 1993 | 1 | adult male & female and 2 fledgling males radio-tagged 1993 |
| Nugget Creek, Mendenhall Glacier | 1993 | 1993 | 1993 | 1 | adult male & female and 2 fledgling females radio-tagged 1993 |
| Mud Bay River, Chichagof Island | 1993 | 1993 | 1993 | 1 | three fledglings observed |

Table 2. **Known nesting in sequential years by Southeast Alaska northern goshawks.**[1]

| Site, Years Active | Distance Between Nests |
|---|---|
| Ready Bullion Crk., Douglas Is., 1991-1992[a,c,f] | 0.30 km (0.20 mi) |
| Big John Crk, Kupreanof Is., 1992-1993[a,c,f] | 0.12 km (0.08 mi) |
| Point Bridget, Juneau, 1992-1993[a,c,f] | 0.35 km (0.22 mi) |
| Point Bridget, Juneau, 1993-1994[b,d,e] | 24.0 km (15.0 mi) |
| Blueberry Hill, Douglas Is., 1993-1994[a,d,e] | 0.20 km (0.12 mi) |
| Nugget Creek, Juneau, 1993-1994[a,c,f] | 0.20 km (0.12 mi) |
| Eagle Creek, Douglas Is., 1993-1994[b,d,e] | 3.2 km (2.0 mi) |
| **Range** | 0.12 km (0.08 mi) - 24.0 km (15.0 mi) |

1 None of 11 nests active since 1989 have been reoccupied. All documented renesting in sequential years has occurred at alternate nests.

a Nest located in same stand.
b Nest located in different stand.
c Nest location unaided by telemetry.
d Nest location aided by telemetry.
e Same adult female both years.
f Status of adult female unknown.

Table 3. Characterization of Southeast Alaska northern goshawk nests sites.

Ketchikan Area

| Nest Site | Elev. | Ground Slope | Slope Aspect | Tree Species | Tree DBH | Nest Height | Nest Aspect |
|---|---|---|---|---|---|---|---|
| Port Refugio, Suemez Island, 1989 | 152 m (500 ft) | 18° | NE | Sitka spruce | 71 cm (28 in) | 13.0 m (43 ft) | E |
| Port Refugio, Suemez Island, 1989[1] | 168 m (550 ft) | 32° | NE | Sitka spruce | 99 cm (39 in) | 9.1 m (30 ft) | NE |
| Port Refugio, Suemez Island, 1992[2] | 168 m (550 ft) | 36° | NW | western hemlock | 76 cm (30 in) | 11.0 m (36 ft) | WSW |
| Sarkar Lake, POWI, 1992 | 30 m (100 ft) | 0° | E | western red cedar | 91 cm (36 in) | 14.0 m (46 ft) | E |
| Logjam Creek, POWI, 1993 | 76 m (250 ft) | 10° | ENE | Sitka spruce | 114 cm (45 in) | 12.0 m (39 ft) | WSW |
| Mean | 119 m (390 ft) | 19° | ------ | -------- | 90 cm (36 in) | 11.8 m (39 ft) | -------- |
| Range | 30 m - 168 m (100 - 550 ft) | 0 - 36° | ------ | -------- | 71 - 114 cm (28 - 45 in) | 9.1 - 14.0 m (30 - 46 ft.) | -------- |

[1] = inactive nest located in 1989.
[2] = inactive nest located in 1993.

Table 3. (cont.)

Stikine Area

| Nest Site | Elev. | Ground Slope | Slope Aspect | Tree Species | Tree DBH | Nest Height | Nest Aspect |
|---|---|---|---|---|---|---|---|
| Starfish, Etolin Island, 1991 | 168 m (550 ft) | 25° | SSW | western hemlock | 64 cm (25 in) | 16.8 m (55 ft) | SSE |
| Big John Creek, Kupreanof Island., 1992 | 122 m (400 ft) | 15° | NE | western hemlock | 49 cm (19 in) | 12.0 m (39 ft) | SSW |
| Big John Creek, Kupreanof Island., 1993 | 152 m (500 ft) | 30° | NNE | western hemlock | 41 cm (16 in) | 11.4 m (37 ft) | NE |
| Rowan Creek, Kupreanof Island, 1993 | 82 m (270 ft) | 10° | ESE | Sitka spruce | 97 cm (38 in) | 13.7 m (45 ft) | E |
| Upper Totem Creek (a), Kupreanof Island, 1993[3] | 134 m (440 ft) | 30° | SSW | western hemlock | 86 cm (34 in) | 13.7 m (45 ft) | SE |
| Upper Totem Creek (b), Kupreanof Island, 1993[3] | 122 m (400 ft) | 30° | SSW | yellow cedar | 69 cm (27 in) | 12.2 m (40 ft) | SSW |
| **Mean** | **130 m (427 ft)** | **23°** | ------ | ------- | **69 cm (27 in)** | **13.3 m (44 ft)** | ------ |
| **Range** | **82 - 168 m (270 - 550 ft)** | **10 - 30°** | ------ | ------- | **64 - 97 cm (25 - 38 in)** | **11.4 - 16.8 m (37 - 55 ft)** | ------ |

[3] = inactive nest located in 1993.

Table 3. (cont.)

## Chatham Area

| Nest Site | Elev. | Ground Slope | Slope Aspect | Tree Species | Tree DBH | Nest Height | Nest Aspect |
|---|---|---|---|---|---|---|---|
| Ready Bullion Creek, Douglas Island, 1992 | 152 m (500 ft) | 3° | S | Sitka spruce | 54 cm (22 in) | 10.5 m (34 ft) | S |
| Blueberry Hill, Douglas Island, 1993 | 198 m (650 ft) | 20° | ENE | Sitka spruce | 78 cm (31 in) | 10.9 m (36 ft) | ESE |
| Eagle Creek, Douglas Island, 1993 | 198 m (650 ft) | 32° | NE | Sitka spruce | 130 cm (51 in) | 12.0 m (39 ft) | SSW |
| Nugget Creek, Mendenhall Glacier, 1993 | 229 m (750 ft) | 10° | WSW | Sitka spruce | 82 cm (32 in) | 25.7 m (84 ft) | ESE |
| Point Bridget, Echo Cove, 1992 | 18 m (60 ft) | 10° | ENE | western hemlock | 41 cm (16 in) | 17.2 m (56 ft) | ESE |
| Point Bridget, Echo Cove, 1993 | 91 m (300 ft) | 15° | ESE | Sitka spruce | 107 cm (42 in) | 10.3 m (34 ft) | SSE |
| Mud Bay River, Chichagof Island, 1993 | 61 m (200 ft) | 22° | NE | Sitka spruce | 82 cm (32 in) | 21.3 m (70 ft) | SE |
| **Mean** | **135 m (444 ft)** | **16°** | ------- | ---------- | **82 cm (32 in)** | **15.4 m (44 ft)** | ----- |
| **Range** | **18 - 229 m 60 - 750 ft)** | **3 - 32°** | ------- | ---------- | **41 - 130 cm (16 - 51 in)** | **10.3 - 25.7 m (34 - 84 ft)** | ----- |

Table 3. (cont.)

Ketchikan, Stikine, and Chatham Areas

| All Nests Combined (n = 18) | Elev. | Ground Slope | Slope Aspect | Tree Species | Tree DBH | Nest Height | Nest Aspect |
|---|---|---|---|---|---|---|---|
| Mean | 129 m (423 ft) | 19° | (see text) | (see text) | 79 cm (31 in) | 13.7 m (45 ft) | (see text) |
| Range | 18 - 229 m (60 - 750 ft) | 0 - 36° | ( " " ) | ( " " ) | 41 - 130 cm (16 - 51 in) | 9.1 - 25.7 m (30 - 84 ft) | ( " " ) |

Table 4. **Prey species identified through gross examination of remains collected at Southeast Alaska northern goshawk nests, 1989 - 1993.**

**Ketchikan Area**

| PREY | NEST SITE | | |
|---|---|---|---|
| | Port Refugio, Suemez Is. 1989 | Sarkar Lake, POWI, 1992 | Logjam Creek, POWI, 1993 |
| Anatidae sp. | | X | |
| greater yellowlegs | X | | |
| Franklin's grouse | X | X | |
| grouse sp. | X | | X |
| sharp-shinned hawk | | X | |
| belted kingfisher | | X | |
| red-breasted sapsucker | | X | |
| woodpecker sp. | | X | X |
| northwestern crow | | X | |
| Steller's jay | X | X | X |
| varied thrush | X | X | |
| unidentified bird | X | X | X |
| unidentified mammal | X | X | |

Table 4. (cont.)

Stikine Area

| PREY | NEST SITE | | | | |
|---|---|---|---|---|---|
| | Starfish, Etolin Island, 1991 | Upper Totem Creek, Kupreanof Is., 1992[1] | Big John Creek, Kupreanof Is., 1992 | Big John Creek, Kupreanof Is., 1993 | Rowan Bay, Kuiu Is., 1993 |
| Alcidae sp. | | | X | X | |
| yellowlegs sp. | X | | | | |
| blue grouse | | | X | | |
| grouse sp. | | X | | X | X |
| sharp-shinned hawk | | | | | X |
| woodpecker sp. | | X | X | | X |
| Steller's jay | X | X | X | X | X |
| varied thrush | | X | X | | X |
| hermit thrush | | | | | X |
| unidentified bird | X | X | X | X | X |
| red squirrel | X | | | X | X |
| unidentified mammal | X | X | X | | |

[1] inactive nest located in 1993; prey remains from nest believed to be active in 1992.

Table 4. (cont.)
Chatham Area

| PREY | NEST SITE | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ready Bull. Creek, Douglas Is., 1992 | Point Bridget, Juneau, 1992 | Point Bridget, Juneau, 1993 | Blueberry Hill, Douglas Is., 1993 | Eagle Creek, Douglas Is., 1993 | Nugget Creek, Juneau, 1993 | Mud Bay River, Chichagof Is., 1993 |
| Alcidae sp. | | | | | | X | |
| shorebird sp. | X | | | | | | |
| blue grouse | X | X | | X | X | | |
| grouse sp. | | | | | X | | |
| ptarmigan sp. | | | | | X | X | |
| sharp-shinned hawk | | X | | | | | X |
| saw-whet owl | | | | | X | | |
| woodpecker sp. | | | | | | | X |
| northwestern crow | | | X | | | | |
| Steller's jay | X | X | X | X | X | X | X |
| varied thrush | | | | X | X | X | |
| unidentified bird | X | X | X | X | X | X | X |
| Lagomorpha sp. | | | | X | | | |
| red squirrel | | | X | X | X | | X |
| unidentified mammal | X | X | | | | | |
| Coleoptera (beetle) | | | | X | | | |

Table 5. Frequency of occurrence of prey remains at 15 northern goshawk nests in Southeast Alaska, 1989 - 1993.[1]

| Species | #.of Nest Sites | % of Nest Sites |
|---|---|---|
| Steller's jay (*Cyanocetti stelleri*) | 15 | 100 |
| grouse sp. (*Dendragapus sp.*) | 11 | 73 |
| varied thrush (*Ixoreus naevius*) | 9 | 60 |
| red squirrel (*Tamiasciurus hudsonicus*) | 7 | 47 |
| woodpecker sp. (including *Sphyrapicus ruber*) | 6 | 40 |
| sharp-shinned hawk (*Accipiter striatus*) | 4 | 27 |
| Alcidae sp. | 3 | 20 |
| yellowlegs sp. (*Tringa sp.*) | 2 | 13 |
| ptarmigan sp. (*Lagopus sp.*) | 2 | 13 |
| northwestern crow (*Corvus carinus*) | 2 | 13 |
| Anatidae sp. | 1 | 7 |
| shorebird | 1 | 7 |
| Northern saw-whet owl (*Aegolius acadicus*) | 1 | 7 |
| belted kingfisher (*Ceryle alcyon*) | 1 | 7 |
| hermit thrush (*Catharus guttatas*) | 1 | 7 |
| Lagomorpha sp. | 1 | 7 |
| Coleaptera sp. (beetle) | 1 | 7 |

[1] Species identified through gross examination of prey remains collected at nest sites. Does not include unidentified birds and mammals.

Table 6. Southeast Alaska northern goshawk morphometric data (mean ± SD, n, range).[1]

| Variable[2] | Adult Male | Juvenile Male | Adult Female | Juvenile Female |
|---|---|---|---|---|
| Mass | 826.5 ± 71.6 (9) (697 - 925) | 849.1 ± 70.4 (8) (767 - 849) | 1073.9 ± 95.7 (7) (920 - 1210) | 1083.0 ± 74.0 (10) (983 - 1200) |
| Wing Chord | 318.1 ± 6.4 (8) (309 - 329) | 318.0 ± 8.7 (8) (305 - 326) | 341.9 ± 6.0 (7) (333 - 347) | 344.4 ± 3.7 (9) (338 - 351) |
| Wing Flat | 321.5 ± 7.0 (8) (310 - 332) | 324.0 ± 8.7 (8) (310 - 333) | 346.3 ± 7.6 (6) (336 - 355) | 346.6 ± 7.2 (7) (335 - 355) |
| Wing Arc | 328.9 ± 5.9 (9) (321 - 340) | 332.6 ± 11.8 (8) (315 - 351) | 354.9 ± 7.4 (8) (342 - 364) | 358.3 ± 5.3 (10) (352 - 367) |
| Tail Length | 224.4 ± 8.0 (9) (211 -235) | 238.6 ± 10.5 (8) (220 - 251) | 259.1 ± 9.6 (8) (246 - 271) | 267.4 ± 8.1 (10) (258 - 281) |
| Hallux | 28.02 ± 0.83 (9) (27.04 - 29.34) | 26.74 ± 1.39 (8) (25.33 - 29.63) | 31.58 ± 1.06 (8) 29.98 - 33.46 | 29.72 ± 1.0 (10) (28.12 - 31.45) |
| Tarsus Width | 6.39 ± 0.27 (9) (6.16 - 7.02) | 6.46 ± 0.54 (8) (5.77 - 7.59) | 8.20 ± 0.37 (8) (7.76 - 8.70) | 7.30 ± 0.41 (10) (6.56 - 7.69) |
| Culmen | 21.94 ± 0.77 (9) (20.96 - 23.61) | 21.28 ± 1.04 (8) (19.84 - 23.24) | 24.27 ± 0.55 (8) (23.50 - 25.10) | 23.05 ± 0.62 (10) (22.12 -24.01) |

[1] All individuals captured at nest sites during breeding season.

[2] Mass in grams, other measurements in millimeters.

Table 7. Northern goshawk wing, tail, and mass measurements (mm, g).[1]

| | Wing | | Tail | | Mass | |
|---|---|---|---|---|---|---|
| | Mean | Range | Mean | Range | Mean | Range |
| Male | 325.5 | 303 - 354 | 245.7 | 226.5 - 280 | 912 | 735 - 1099 |
| Female | 333.6 | 321 - 368 | 278.6 | 250 - 301 | 1137 | 845 - 1364 |

[1] From Johnsgard (1990).

Table 10. Comparison of Southeast Alaska northern goshawk plumage with literature descriptions for *A.g. laingi* and *A.g. atricapillus.*

## A. Adults [1]

| Goshawk: Sex/Band #/Nest Site | Plumage Distinction/Score | | | |
|---|---|---|---|---|
| | A | B | C | Total |
| **Area 1** | | | | |
| F/1387-64171/Sarkar Lk., Prince of Wales Is. | 6 | 7 | 6 | 19 |
| M/1807-41951/Sarkar Lk., Prince of Wales Is. | 7 | 5 | 5 | 17 |
| M/1807-41965/Logjam Crk., Prince of Wales Is. | 7 | 6 | 6 | 19 |
| **Mean, Area 1** | 7.0 | 6.0 | 5.7 | 18.3 |
| **Area 2** | | | | |
| F/1387-64180/Big John Creek, Kupreanof Island | 9 | 10 | 10 | 29 |
| M/1807-41962/Big John Creek, Kupreanof Island | 7 | 5 | 7 | 19 |
| F/1387-64183/Rowan Creek, Kuiu Island | 6 | 10 | 10 | 27 |
| M/1807-41964/Rowan Creek, Kuiu Island | 7 | 7 | 7 | 21 |
| **Mean, Area 2** | 7.3 | 7.8 | 8.5 | 23.8 |
| **Area 3** | | | | |
| F/1387-64173/Ready Bullion Crk., Douglas Is. | 3 | 7 | 6 | 16 |
| M/1807-41953/Ready Bullion Crk., Douglas Is. | 7 | 7 | 5 | 19 |
| F/1387-64177/Blueberry Hill, Douglas Island | 5 | 8 | 7 | 20 |
| M/1807-41956/Blueberry Hill, Douglas Island | 7 | 6 | 5 | 18 |
| F/1387-02003/Nugget Creek, Juneau | 6 | 7 | 7 | 20 |
| M/1807-41957/Nugget Creek, Juneau | 7 | 5 | 5 | 17 |
| F/1387-64178/Point Bridget, Juneau | 3 | 6 | 5 | 14 |
| M/1387-64179/Point Bridget, Juneau | 4 | 8 | 6 | 18 |
| F/1387-64182/Eagle Creek, Douglas Island | --incomplete photo records-- | | | |
| M/1807-41963/Eagle Creek, Douglas Island | 6 | 5 | 5 | 16 |
| **Mean, Area 3** | 5.3 | 6.6 | 5.7 | 17.6 |
| **Mean: Areas 1, 2, and 3 Combined** | 6.1 | 6.8 | 6.4 | 19.3 |
| **Range: Areas 1, 2, and 3 Combined** | 3 - 9 | 5 - 10 | 5 - 10 | 14 - 25 |

1 See footnotes on page xx for description of scoring, plumage distinctions, and Areas.

Table 10. (cont.)

B. Juveniles [1]

| Goshawk: Sex/Band #/Nest Site | Plumage Description/Score | | | |
|---|---|---|---|---|
| | A | B | C | Total |
| **Area 1** | | | | |
| M/1807-41952/Sarkar Lk., Prince of Wales Is. | 8 | 7 | 7 | 24 |
| M/1807-41954/Sarkar Lk., Prince of Wales Is. | 7 | 6 | 5 | 18 |
| M/1807-41966/Logjam Crk., Prince of Wales Is. | 9 | 7 | 6 | 22 |
| **Mean: Area 1** | 8.0 | 6.7 | 6.0 | 21.3 |
| **Area 2** | | | | |
| F/1387-64174/Big John Creek, Kupreanof Island | 7 | 2 | 3 | 12 |
| F/1387-64175/Big John Creek, Kupreanof Island | 7 | 2 | 3 | 12 |
| F/1387-64180/Big John Creek, Kupreanof Island | 7 | 7 | 2 | 16 |
| M/1807-41955/Falls Creek, Mitkof Island | 9 | 7 | 8 | 24 |
| F/1387-64184/Rowan Creek, Kuiu Island | 9 | 8 | 2 | 19 |
| F/1387-64185/Rowan Creek, Kuiu Island | 8 | 7 | 2 | 17 |
| **Mean: Area 2** | 7.8 | 5.5 | 3.3 | 16.7 |
| **Area 3** | | | | |
| F/1387-64172/Ready Bullion Crk., Douglas Is. | 8 | 7 | --incomplete p. r.-- | |
| F/1387-64177/Blueberry Hill, Douglas Island | 6 | 6 | 3 | 15 |
| M/1807-41967/Eagle Creek, Douglas Island | 8 | 6 | 2 | 16 |
| M/1807-41968/Eagle Creek, Douglas Island | 8 | 6 | 2 | 16 |
| F/1387-64196/Nugget Creek, Juneau | 6 | 6 | 4 | 16 |
| F/1387-64197/Nugget Creek, Juneau | 6 | 7 | 4 | 17 |
| M/1807-41959/Point Bridget, Juneau | --incomplete photo records-- | | | |
| M/1807-41960/Point Bridget, Juneau | --incomplete photo records-- | | | |
| **Mean: Area 3** | 7.0 | 6.3 | 3.0 | 16.0 |
| **Mean: Areas 1, 2, and 3 Combined** | 7.5 | 6.1 | 3.8 | 17.4 |
| **Range: Areas 1, 2, and 3 Combined** | 6 - 9 | 2 - 8 | 2 - 7 | 15 - 24 |

1 See footnotes on page xx for description of scoring, plumage distinctions, and Areas.

Table 10. (cont.)

1 Color photo records and field notes of adult and juvenile northern goshawks captured Southeast Alaska nest sites were used to score the relative similarity of each individual's plumage to three plumage distinctions (A, B, and C) taken from literature descriptions for *laingi* and *atricapillus* (Taverner 1940, Beebe 1974). Score possibilities for each plumage distinction ranged from "10", indicating complete similarity to the darkest extreme described for *A.g. laingi* to "0", indicating complete similarity to the lightest extreme described for *A.g. atricapillus*. For each goshawk and Area mean, the possible range of total scores (A + B + C) is from "30", indicating complete similarity to the darkest *laingi* description, to "0", indicating complete similarity to the lightest *atricapillus* description.

Adults

| Plumage Distinction | *A.g. laingi* ("10") | *A.g. atricapillus* ("0") |
|---|---|---|
| A | Black of crown and nape extends dorsally over shoulders and interscapulars. | Crown is black. Dorsal surface from nape to tail is a uniform pale slate or bluish-grey. |
| B | Ventral surface is coarsely barred and sooty grey, especially across breast. | Ventral surface with fine grey barring on white ground color, resulting in pale-grey appearance. |
| C | Ventral shaftline marks forming vertical streaking are wide and black. | Ventral shaftline marks forming vertical streaking are narrow and grey. |

Juveniles

| Plumage Distinction | *A.g. laingi* ("10") | *A.g. atricapillus* ("0") |
|---|---|---|
| A | Dorsal surface mostly or completely dark brown. | Dorsal surface pale brown. |
| B | Dorsal feathers with little or no lighter feather edging or semi-concealed spots. | Dorsal feathers all darker subterminally with wide, light-brown edges or tips making entire dorsal surface look barred. |
| C | Ground color of ventral surface (breast) is cinnamon-buff to light-buff with many broad and very dark (brown) streaks. | Ground color of ventral surface is pale tawny to white with dark brown streaks. |

Area 1 = Southeast Alaska south of 56° 30' N (Coffman Cove, Prince of Wales Island).
Area 2 = 56° 30' N to 57° 30' N (Coffman Cove, Prince of Wales Island to Angoon, Admiralty Island).
Area 3 = North of 57° 30' N (Angoon, Admiralty Island).

Table 11. Northern goshawk blood samples collected from Southeast Alaska, November, 1991 - August, 1993.

| Blood Sample | Date Collected | USFWS Band # | Goshawk | Location |
|---|---|---|---|---|
| NG 1 | 11/23/91 | (none) | juvenile male | Petersburg, Mitkof Island |
| NG 2 | 06/10/92 | 1387-64171 | adult female | Sarkar Lake, Prince of Wales Island |
| NG 3 | 06/10/92 | 1807-41951 | adult male | Sarkar Lake, Prince of Wales Island |
| NG 4 | 07/28/92 | 1807-41954 | juvenile male | Sarkar Lake, Prince of wales Island |
| NG 5 | 07/02/92 | 1387-64173 | adult female | Ready Bullion Creek, Douglas Island |
| NG 6 | 07/02/92 | 1807-41953 | adult male | Ready Bullion Creek, Douglas Island |
| NG 7 | 08/12/92 | 1387-64174 | juvenile female | Big John Creek, Kupreanof Island |
| NG 8 | 08/12/92 | 1387-64175 | juvenile female | Big John Creek, Kupreanof Island |
| NG 9 | 08/14/92 | 1807-41955 | juvenile male | Falls Creek, Mitkof Island |
| NG 10 | 09/08/92 | 1807-41961 | juvenile female | Hungary Point, Mitkof Island |
| NG 11 | 06/29/93 | 1387-64177 | adult female | Blueberry Hill, Douglas Island |
| NG 12 | 06/29/93 | 1807-41956 | adult male | Blueberry Hill, Douglas Island |
| NG 13 | 08/13/93 | 1387-64198 | juvenile female | Blueberry Hill, Douglas Island |
| NG 14 | 07/01/93 | 1387-02003 | adult female | Nugget Creek, Juneau |
| NG 15 | 07/01/93 | 1807-41957 | adult male | Nugget Creek, Juneau |
| NG 16 | 08/09/93 | 1387-64196 | juvenile female | Nugget Creek, Juneau |
| NG 17 | 08/09/93 | 1387-64197 | juvenile female | Nugget Creek, Juneau |
| NG 18 | 07/06/93 | 1387-64178 | adult female | Point bridget, Juneau |
| NG 19 | 07/06/93 | 1387-64179 | adult male | Point Bridget, Juneau |
| NG 20 | 08/16/93 | 1807-41959 | juvenile male | Point Bridget, Juneau |
| NG 21 | 08/16/93 | 1807-41960 | juvenile male | Point Bridget , Juneau |
| NG 22 | 07/23/93 | 1387-64182 | adult female | Eagle Creek, Douglas Island |
| NG 23 | 07/23/93 | 1807-41963 | adult male | Eagle Creek, Douglas Island |
| NG 24 | 08/13/93 | 1807-41967 | juvenile male | Eagle Creek, Douglas Island |

Table 11. (cont.)

| Blood Sample | Date Collected | USFWS Band # | Goshawk | Location |
|---|---|---|---|---|
| NG 25 | 08/13/93 | 1807-41968 | juvenile male | Eagle Creek, Douglas Island |
| NG 26 | 07/13/93 | 1387-64181 | adult female | Big John Creek, Kupreanof Island |
| NG 27 | 07/13/93 | 1807-41962 | adult male | Big John Creek,Kupreanof Island |
| NG 28 | 08/19/93 | 1387-64180 | juvenile female | Big John Creek, Kupreanof Island |
| NG 29 | 07/28/93 | 1387-64183 | adult female | Rowan Creek,Kuiu Island |
| NG 30 | 07/28/93 | 1807-41964 | adult male | Rowan Creek, Kuiu Island |
| NG 31 | 08/16/93 | 1387-64184 | juvenile female | Rowan Creek, Kuiu Island |
| NG 32 | 08/17/93 | 1387-64185 | juvenile female | Rowan Creek, Kuiu Island |
| NG 33 | 08/04/93 | 1807-41965 | adult male | Logjam Creek, Prince of Wales Island |
| NG 34 | 08/04/93 | 1807-41966 | juvenile male | Logjam Creek,Prince of Wales Island |
| NG 35 | 03/10/92 | 1387-02004 | juvenile female | Sunny Point, Juneau |

Table 12. Adult goshawk (n = 16) minimum convex polygon (MCP) breeding home range size (ha) including salt water. Breeding season included from mid- to late-nestling up to juvenile dispersal.

| Nest Site | Male MCP Home Range Size | n | Female MCP Home Range Size | n | Combined MCP Home Range Size |
|---|---|---|---|---|---|
| CHATHAM AREA | | | | | |
| Ready Bullion | 2,009 | 9 | 700 | 9 | 2,104 |
| Blueberry Hill | 1,915 | 10 | 1,352 | 10 | 2,973 |
| Eagle Creek[1] | 728 | 8 | 4,121 | 10 | 4,457 |
| Nugget Creek | 4,505 | 10 | 847 | 14 | 5,125 |
| Point Bridget | 3,460 | 8 | 273 | 10 | 3,606 |
| STIKINE AREA | | | | | |
| Rowan Bay[1] | 6,240 | 24 | 10,823 | 24 | 14,932 |
| Big John[2] | 8,514 | 50 | 111,407 | 30 | 116,817 |
| KETCHIKAN AREA | | | | | |
| Sarkar Lake[2] | 19,407 | 37 | 24,199 | 25 | 41,764 |

[1] = Adults radio-tagged during fledgling dependency period.

[2] = Female abandoned nest site during fledgling dependency period.

**Table 13. Adult goshawk (n = 17) minimum convex polygon (MCP) total home range size (ha) including salt water. Total home range included nesting and post-nesting periods .**

| Nest Site | Male MCP Home Range Size | n | Female MCP Home Range Size | n | Combined MCP Home Range Size |
|---|---|---|---|---|---|
| **CHATHAM AREA** | | | | | |
| Ready Bullion[1] | 2,009 | 13 | 804 | 11 | 2,180 |
| Blueberry Hill[2] | 3,604 | 18 | 4,131 | 18 | 4,763 |
| Eagle Creek[2] | 946 | 10 | 4,231 | 15 | 5,014 |
| Nugget Creek[3] | 4,523 | 17 | 3,107 | 21 | 7,052 |
| Point Bridget[2] | 5,843 | 16 | 7,652 | 13 | 11,944 |
| **STIKINE AREA** | | | | | |
| Rowan Bay[2] | 12,897 | 41 | 16,596 | 41 | 20,807 |
| Big John[2] | 17,521 | 76 | 129,861 | 46 | 141,779 |
| **KETCHIKAN AREA** | | | | | |
| Sarkar Lake[4] | 67,599 | 55 | 141,351 | 70 | 170,674 |
| Logjam Creek[2] | 12,035 | 21 | NA | | NA |

[1] = Home range size (7/10/92 to 9/23/92).

[2] = Adult home range size from 1993 nesting period to 11/07/93.

[3] = Male home range size (7/08/93 to 11/04/93). Female home range size (4/11/93 to 11/04/93).

[4] = Male home range size (6/17/93 to 3/10/93). Female home range size (6/17/92 to 11/03/93).

**Table 14. Ninety and fifty percent harmonic mean breeding home range size (ha) for 16 radio-tagged adult northern goshawks in Southeast Alaska, 1992-1993. For the harmonic mean analysis, relocations were centered in 40x40 grid cells. Breeding season included from mid- to late-nestling period up to juvenile dispersal.**

| NEST SITE | SEX | 90% HM | 50% HM | N= |
|---|---|---|---|---|
| CHATHAM AREA | | | | |
| Blueberry Hill | F | 670 | 180 | 11 |
| " " | M | 539 | 155 | 11 |
| Eagle Creek[1] | F | 992 | 632 | 11 |
| " " | M | 177 | 43 | 9 |
| Nugget Creek | F | 516 | 22 | 15 |
| " " | M | 1,608 | 435 | 11 |
| Point Bridget | F | 84 | 48 | 11 |
| " " | M | 1,218 | 128 | 9 |
| Ready Bullion | F | 140 | 65 | 10 |
| " " | M | 672 | 237 | 10 |
| STIKINE AREA | | | | |
| Big John[2] | F | 16,426 | 6,232 | 31 |
| " " | M | 6,613 | 1,381 | 51 |
| Rowan Bay[1] | F | 6,020 | 1,345 | 25 |
| " " | M | 3,009 | 681 | 25 |
| KETCHIKAN AREA | | | | |
| Sarkar Lake[2] | F | 19,613 | 3,917 | 26 |
| " " | M | 10,378 | 2,305 | 38 |

[1] = Adults radio-tagged during fledgling dependency period.

[2] = Female abandoned nest site during fledgling dependency period.

Table 15. Ninety and fifty percent harmonic mean total home range size (ha) for 17 radio-tagged adult northern goshawks in Southeast Alaska, 1992-1993. For the harmonic mean analysis, relocations were centered in 40x40 grid cells. Total home range included nesting and post-nesting periods. See footnotes for Table 13.

| NEST SITE | SEX | 90% HM | 50% HM | N= |
|---|---|---|---|---|
| CHATHAM AREA | | | | |
| Blueberry Hill | F | 1,201 | 573 | 19 |
| " " | M | 2,099 | 396 | 19 |
| Eagle Creek | F | 2,314 | 983 | 16 |
| " " | M | 272 | 128 | 11 |
| Nugget Creek | F | 1,940 | 313 | 22 |
| " " | M | 2,267 | 994 | 18 |
| Point Bridget | F | 5,304 | 996 | 14 |
| " " | M | 6,255 | 656 | 13 |
| Ready Bullion | F | 253 | 79 | 12 |
| " " | M | 1,445 | 233 | 14 |
| STIKINE AREA | | | | |
| Big John | F | 25,761 | 8,815 | 47 |
| " " | M | 10,807 | 4,077 | 77 |
| Rowan Bay | F | 14,667 | 2,024 | 42 |
| " " | M | 4,329 | 838 | 42 |
| KETCHIKAN AREA | | | | |
| Sarkar Lake | F | 114,728 | 31,422 | 71 |
| " " | M | 60,949 | 6,990 | 56 |
| Logjam Creek | M | 8,899 | 1,896 | 22 |

Table 16. Fledging and dispersal of juvenile northern goshawks radio-tagged at Southeast Alaska nest sites.

| Area/ Goshawk | Est. Date Fledged[1] | Est. Date Dispersed[2] | Post-Fledgling Period (d)[3] | Max. Dispersal Dist. km (mi)[4] | Date of Max. Dispersal[5] |
|---|---|---|---|---|---|
| **Ketchikan** | | | | | |
| SLM2 | 07/03/92 | 08/13/92 | 41 | NA[6] | NA[6] |
| SLM3 | 06/29/92 | 08/05/92 | 37 | NA[6] | NA[6] |
| LJM2 | 07/21/93 | 08/27/93 | 37 | 149.8 (93.6) | 10/05/93 |
| **Stikine** | | | | | |
| BJF2 | 07/27/93 | 09/05/93 | 40 | 54.1 (33.8) | 12/28/93 |
| RNF2 | 07/24/93 | 09/05/93 | 43 | 151.1 (94.4) | 01/05/94 |
| RNF3 | 07/24/93 | 08/28/93 | 32 | 47.9 (29.9) | 09/30/93 |
| **Chatham** | | | | | |
| RBF2 | 07/20/92 | 08/27/93 | 38 | 15.9 (9.9) | 01/13/93 |
| BBF2 | 07/04/93 | 08/16/93 | 43 | 52.6 (32.9) | (10/11/93) |
| NCF2 | 07/13/93 | 08/22/93 | 40 | 51.9 (32.4) | (10/11/93) |
| NCF3 | 07/11/93 | 08/22/93 | 42 | 87.4 (54.6) | 10/11/93 |
| PBM2 | 07/20/93 | 08/22/93 | 37 | 29.0 (18.1) | (08/27/93) |
| PBM3 | 07/18/93 | 08/22/93 | 35 | 32.0 (20.0) | 10/11/93 |
| ECM2 | 07/18/93 | 09/03/93 | 47 | NA[6] | NA[6] |
| ECM3 | 07/16/93 | 08/25/93 | 40 | 38.2 (23.9) | (08/27/93) |
| | | | | | |
| **Mean** | 07/16/93 | 08/24/93 | 40 | 64.5 (40.3) | — |
| **Range** | 06/29 - 07/27 | 08/05 - 09/05 | 35 - 47 | 15.9 (9.9) - 151.1 (94.4) | 08/27 - 01/13 |

1 Date estimated using observed level of nestling and fledgling physical development (McGowan 1975) and 36 and 42 days fledging age for males and females, respectively (Johnsgard 1990).

2 Date based on first relocation greater than 1.5 km (0.94 mi) from nest tree (Kenward, et al. 1993).

3 Equals duration of period between fledging and dispersal.

4 Maximum distance recorded. Distance calculated on USFS GIS as straight line between nest tree and most distant relocation. Includes data recorded through January 13.

5 Date in parentheses equal last recorded relocation for bird.

6 Data not available. Bird could not be relocated after dispersal.

**Figure 1. Mean wing chords of adult male northern goshawks from Southeast Alaska compared with other regions.**

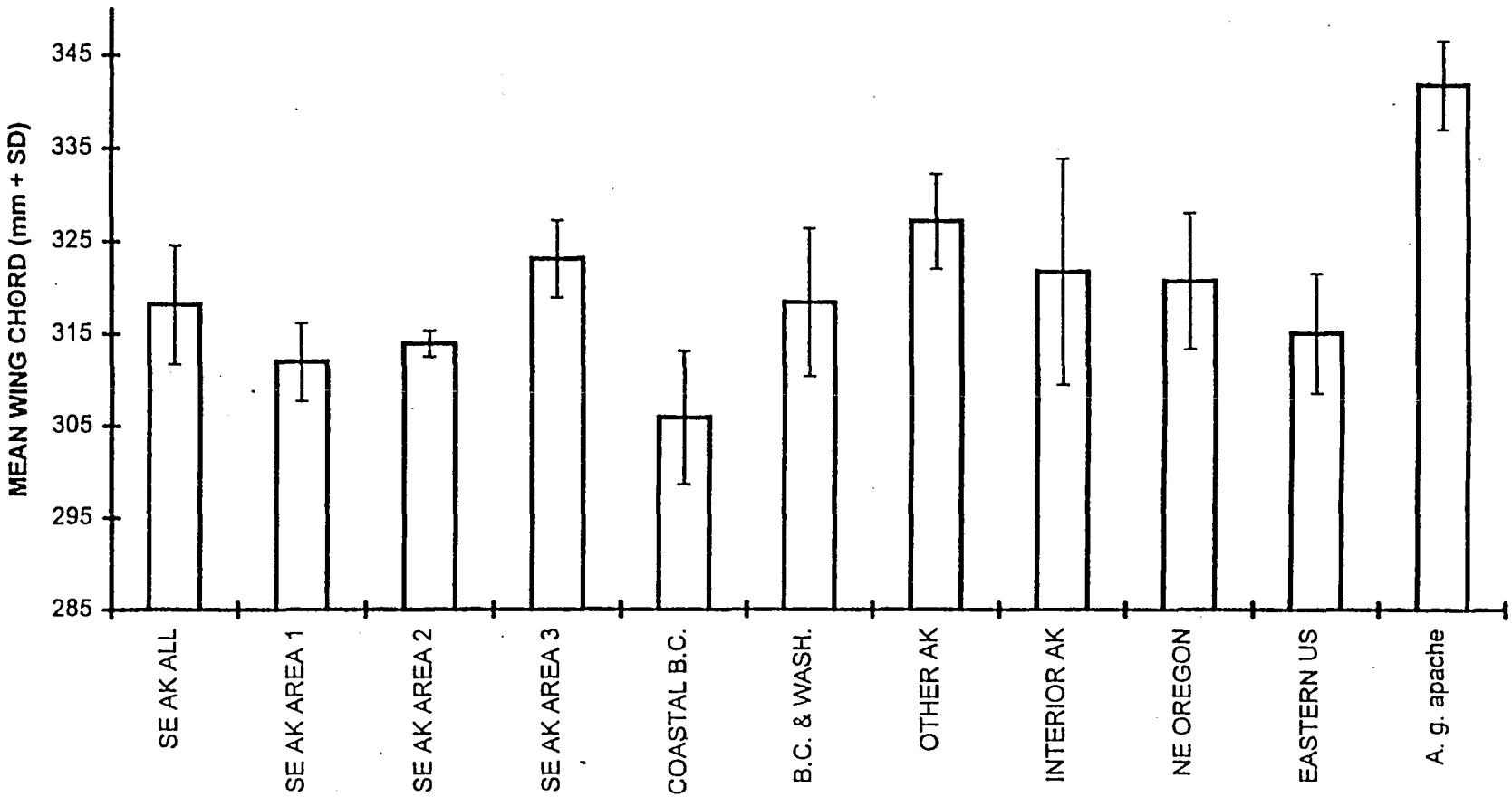


**Figure 2. Mean wing chords of adult female northern goshawks from southeast Alaska compared with other regions.**

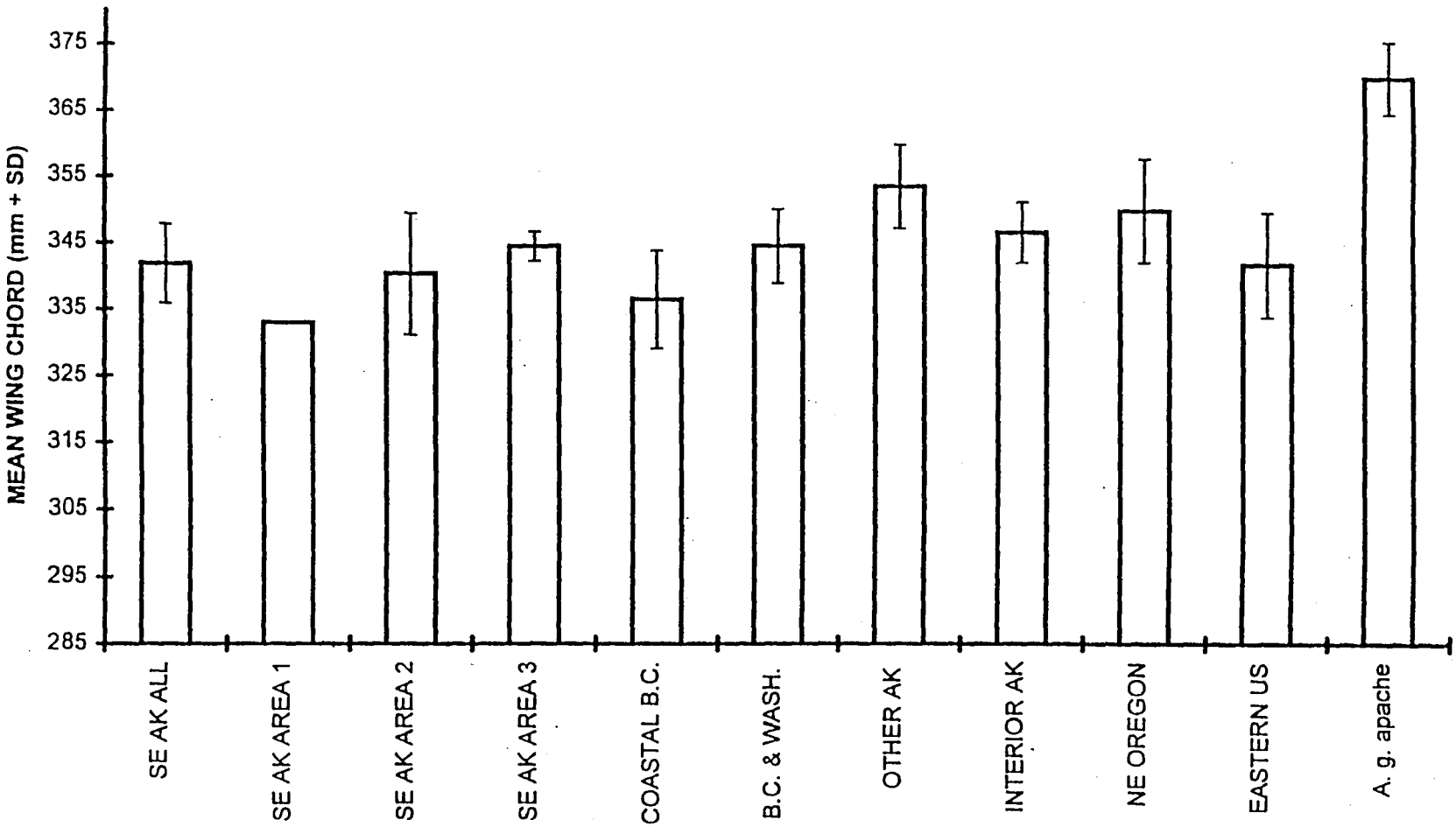


**Figure 3. Adult northern goshawk breeding season minimum convex polygon season home range sizes compared with number of relocations.**

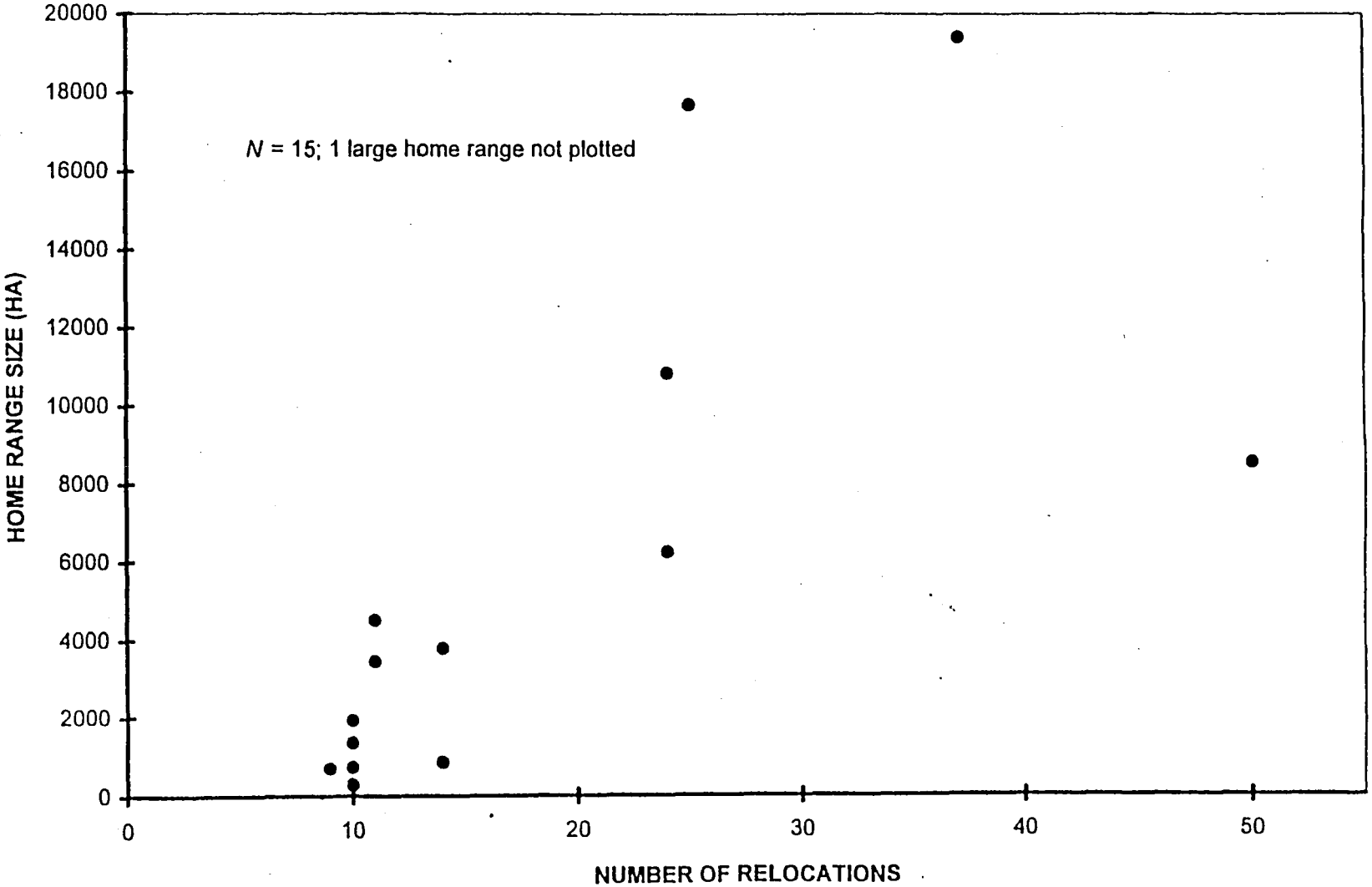


**Figure 4. Total adult northern goshawk minimum convex polygon home range sizes compared with number of relocations.**

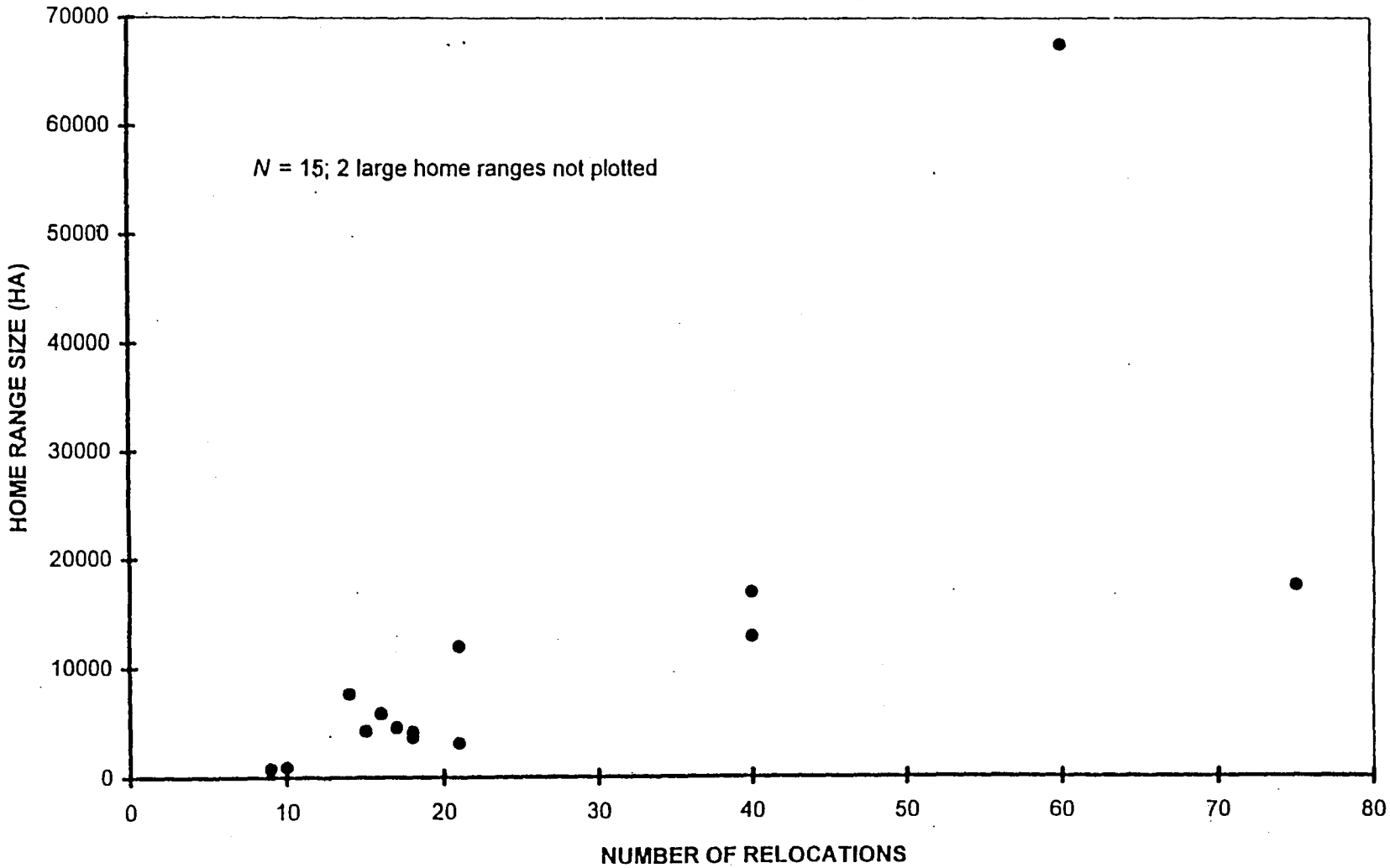


**Figure 5. 90% Harmonic mean breeding season adult northern goshawk home range sizes compared with number of relocations.**

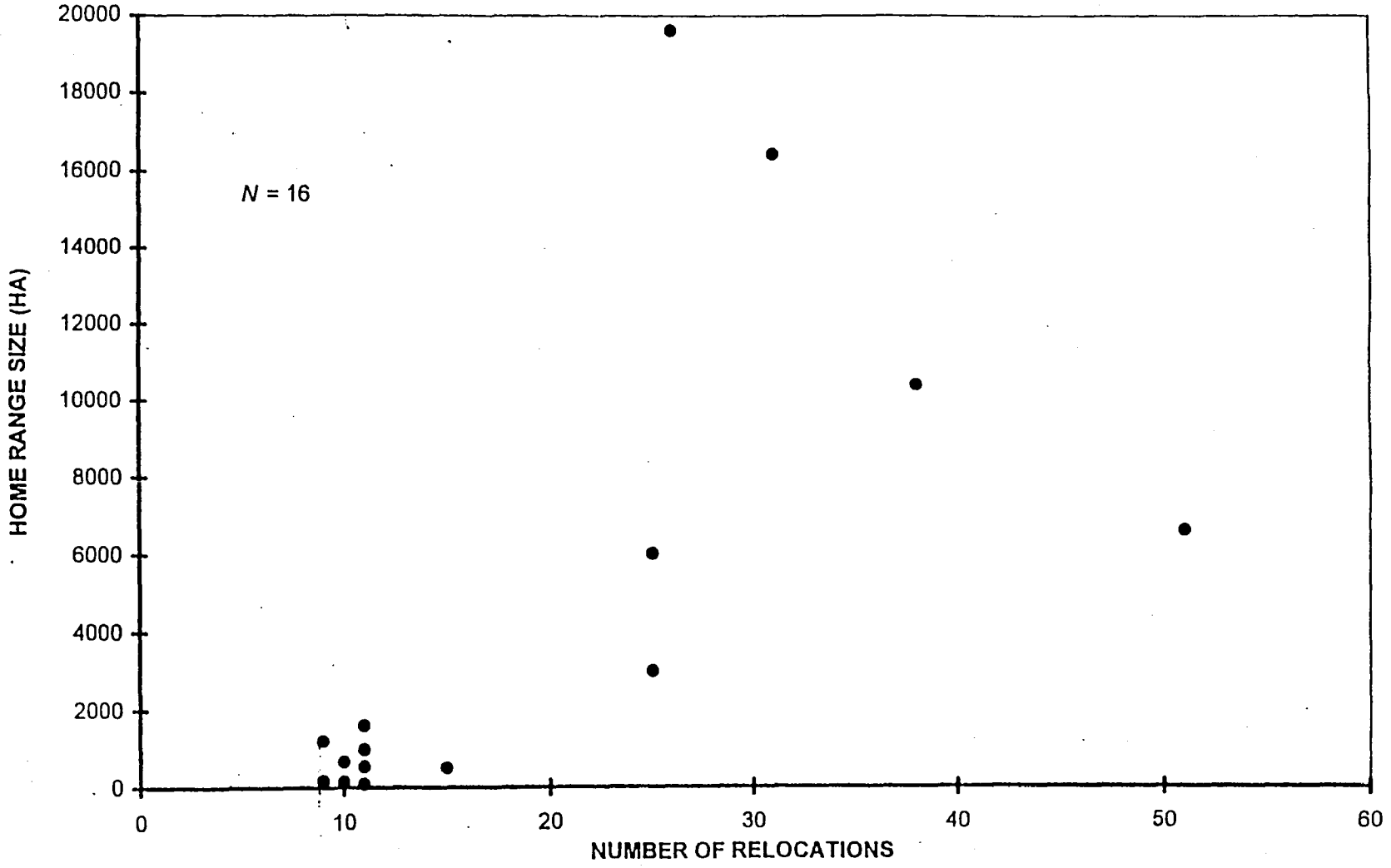


**Figure 6. 90% Harmonic mean total adult northern goshawk home range sizes compared with number of relocations.**

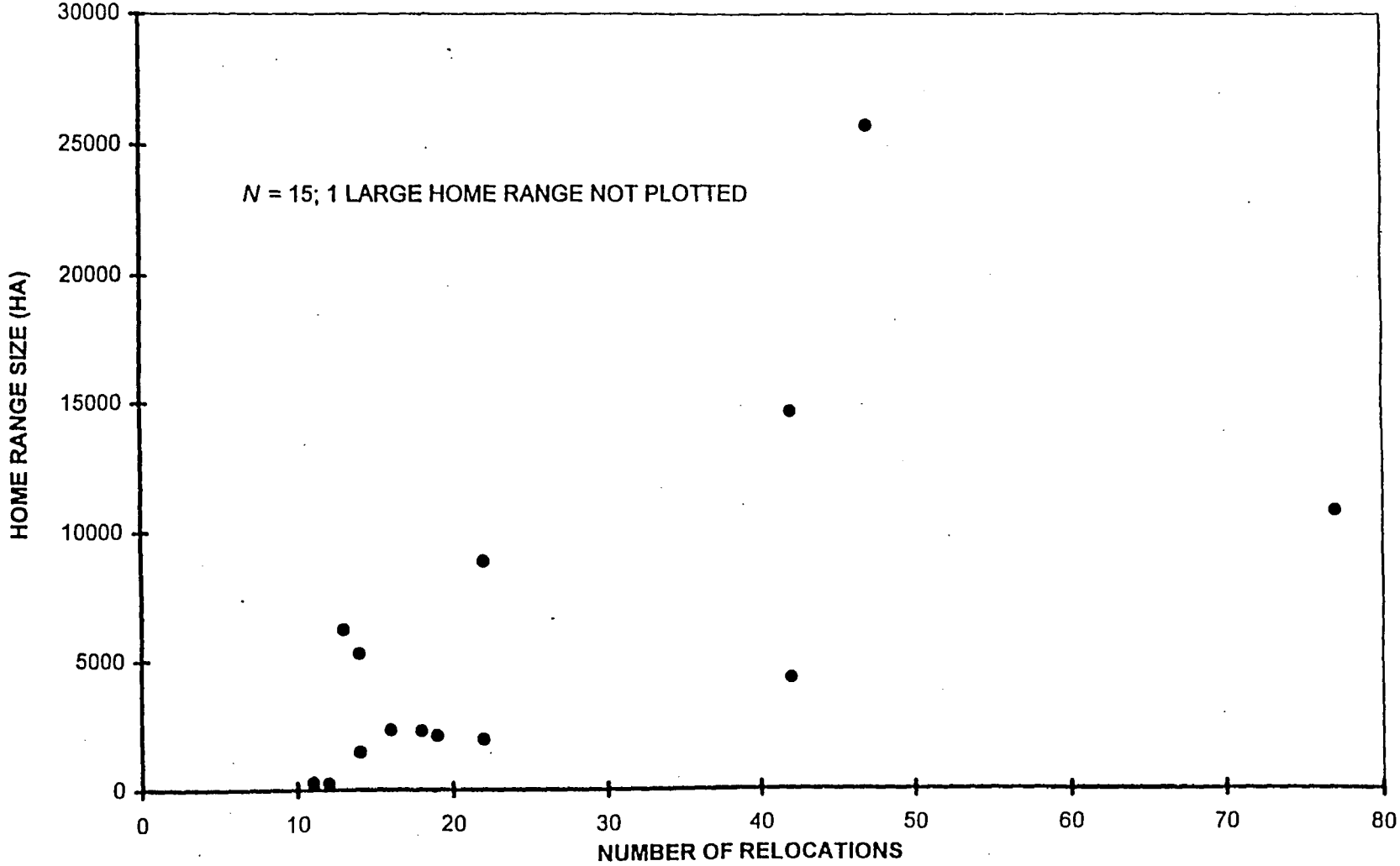


**Figure 7. Occurrence of northern goshawk telemetry locations by habitat type based on aerial estimates. Data pooled by sex and age.**

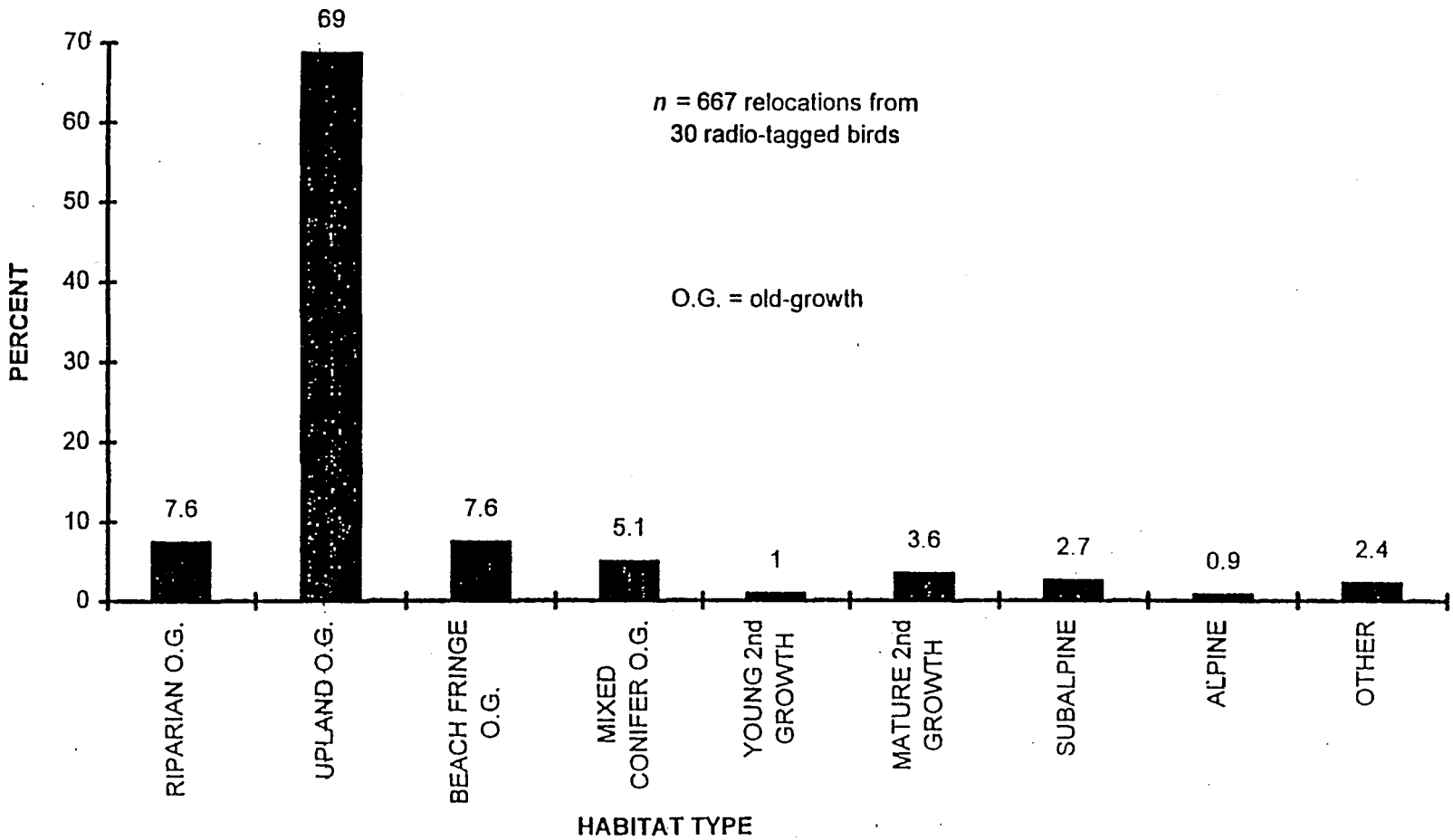
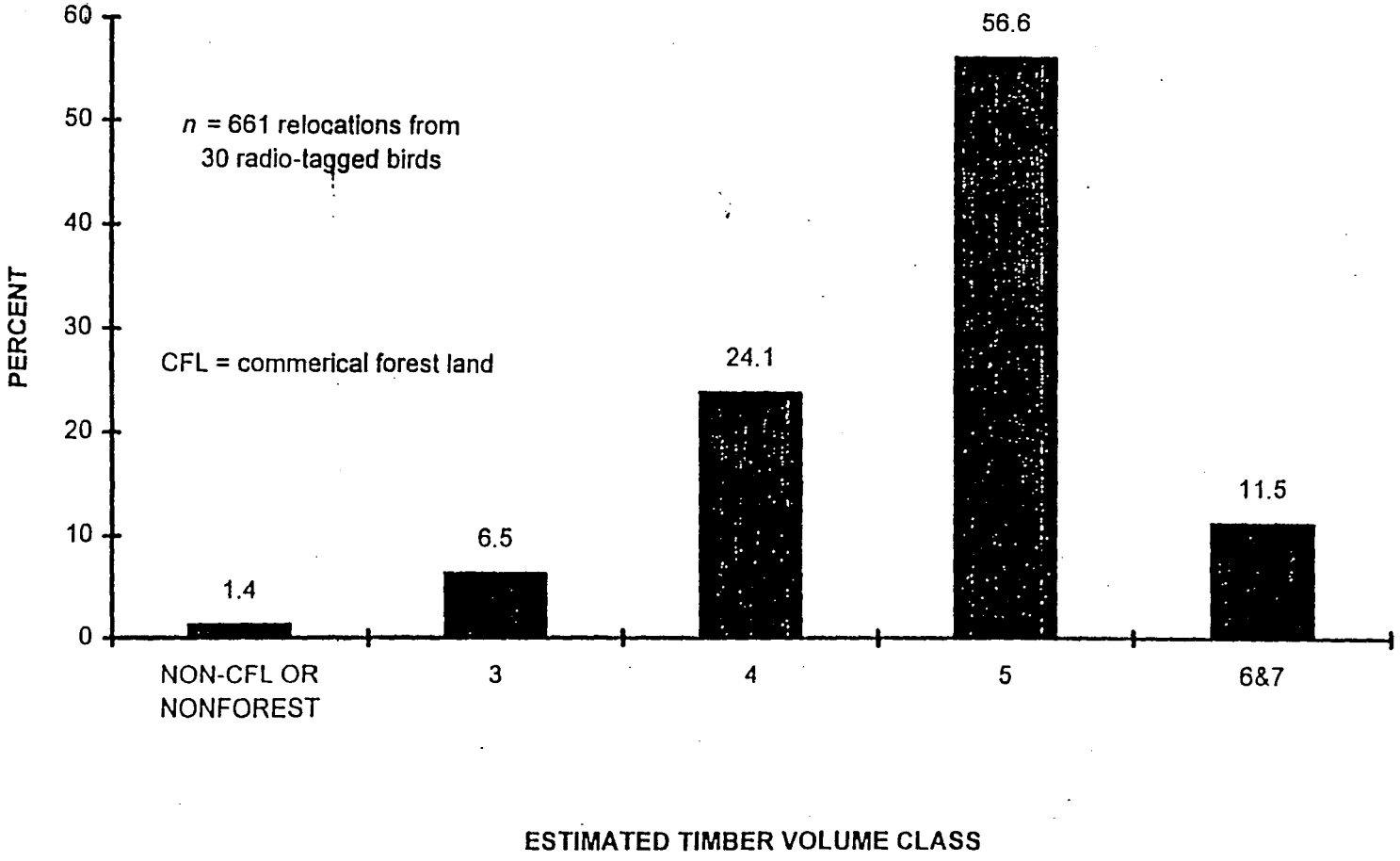


**Figure 8. Occurrence of northern goshawk telemetry locations by timber volume class based on aerial estimates. Data pooled by sex and age.**



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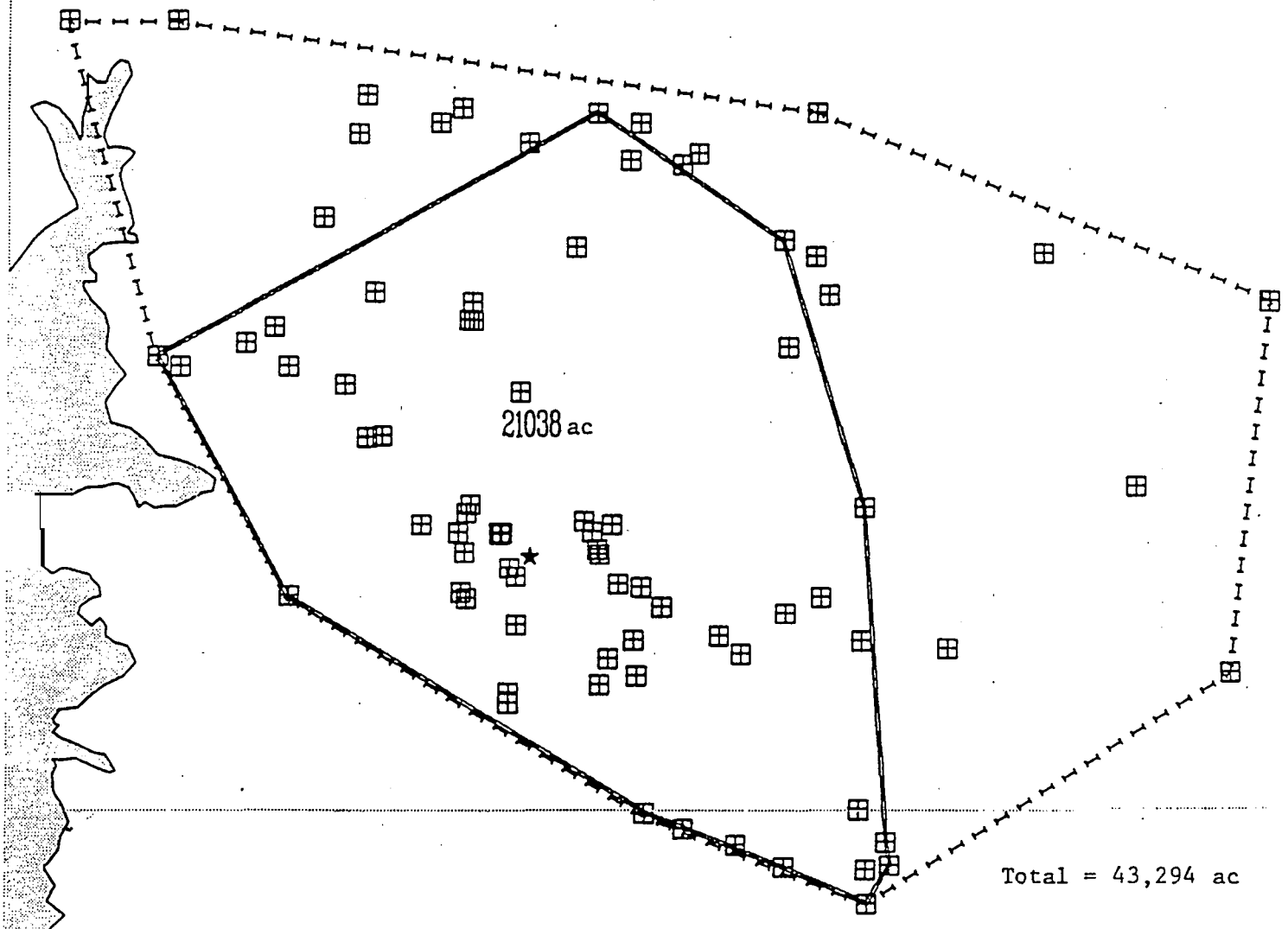
**Appendix I.** Adult northern goshawk minimum convex polygon (MCP) breeding, total, pair combined breeding, and pair combined total home range maps. Breeding home ranges were constructed using all independent relocations collected during the nesting period up until the time of juvenile dispersal. Total home ranges were calculated using all independent relocations collected during both the nesting and post-nesting periods up to November 1993. With the exception of SLF1 (16 months) , SLM1 (9 months), RBF1 (6 month) and RBM1 (2 months) which were radio-tagged in 1992, total home ranges were constructed using data collected during the 3 - 5 month period between June and November 1993. MCP home range maps and area estimates provided by E. J. DeGayner using U.S. Forest Service's Geographic Information System (GIS).

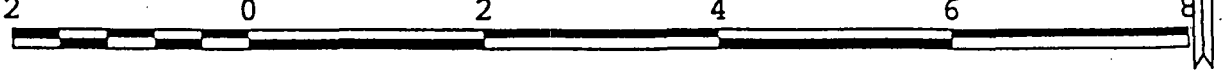
Abbreviations follow:

BB = Blueberry Hill (Douglas Island)
BJ = Big John Creek (Kupreanof Island)
EC = Eagle Creek (Douglas Island)
LJ = Logjam Creek (Prince of Wales Island)
NC = Nugget Creek (Mainland)
PB = Point Bridget (Mainland)
RB = Ready Bullion Creek (Douglas Island)
RN = Rowan Bay (Kuiu Island)
SL = Sarkar Lake (Prince of Wales Island)

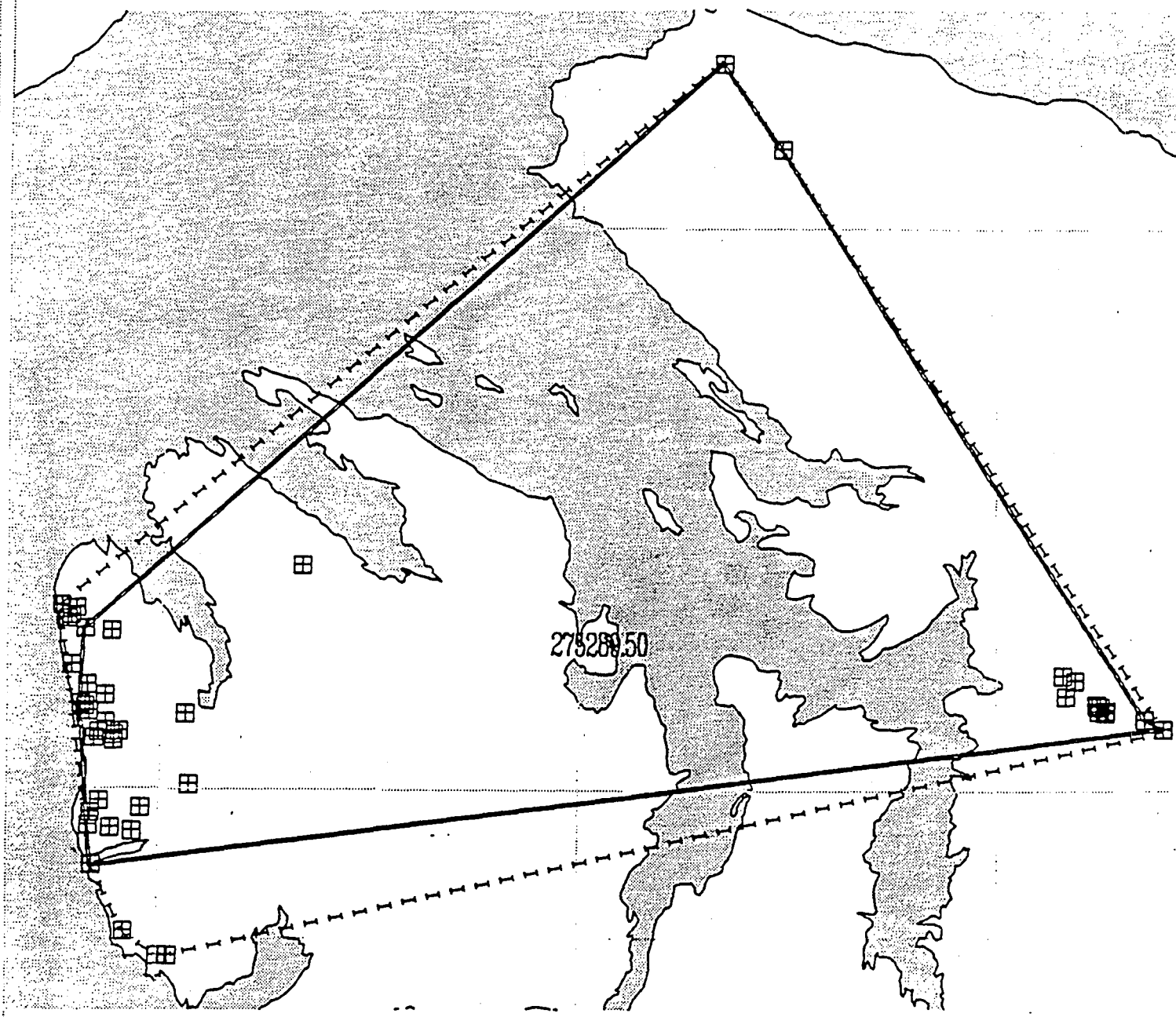
F1 = Adult Female
M1 = Adult Male




MAPSCALE 1:106030



TOTAL AND BREEDING MCP HOME RANGES FOR BJF1

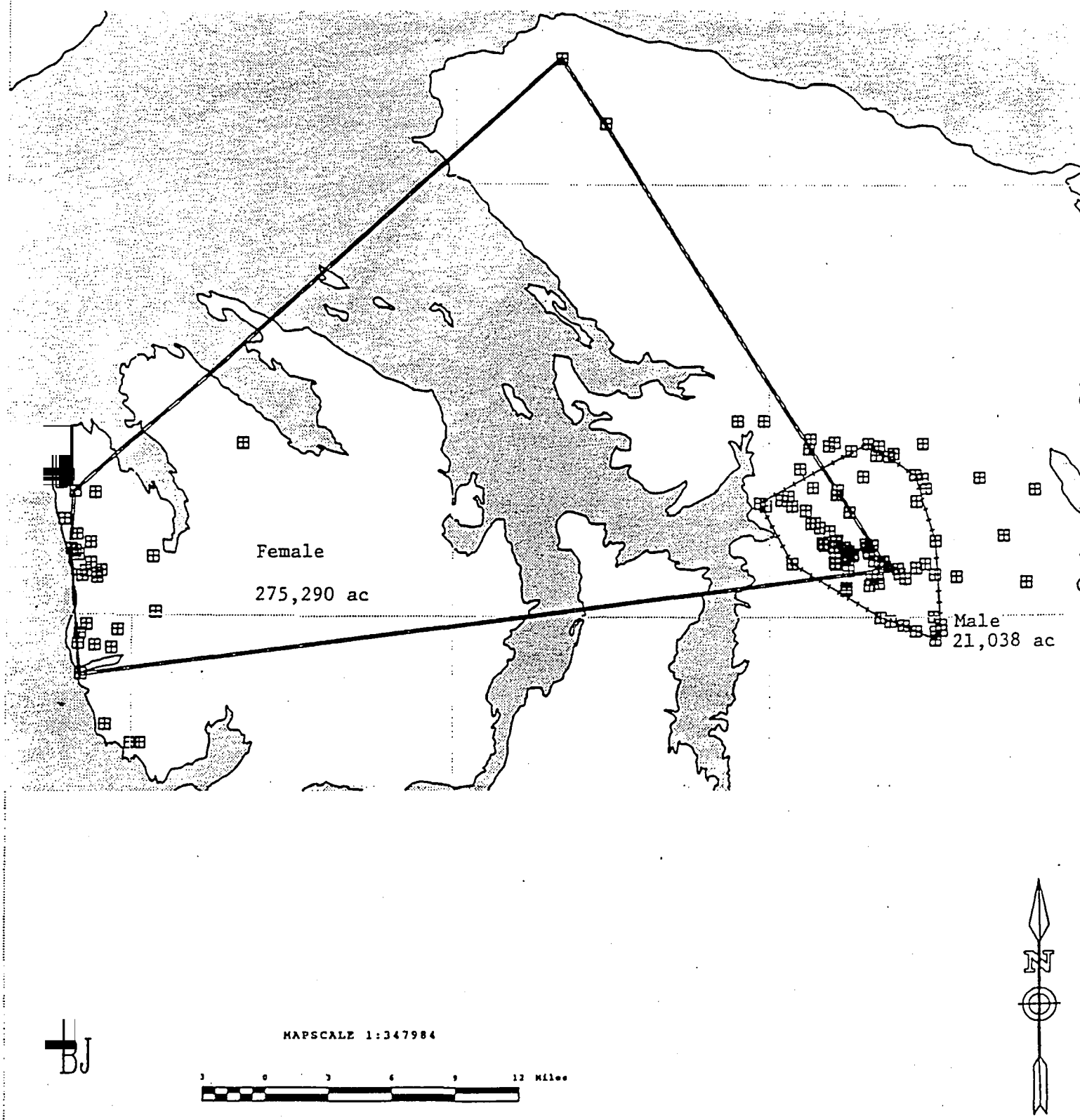


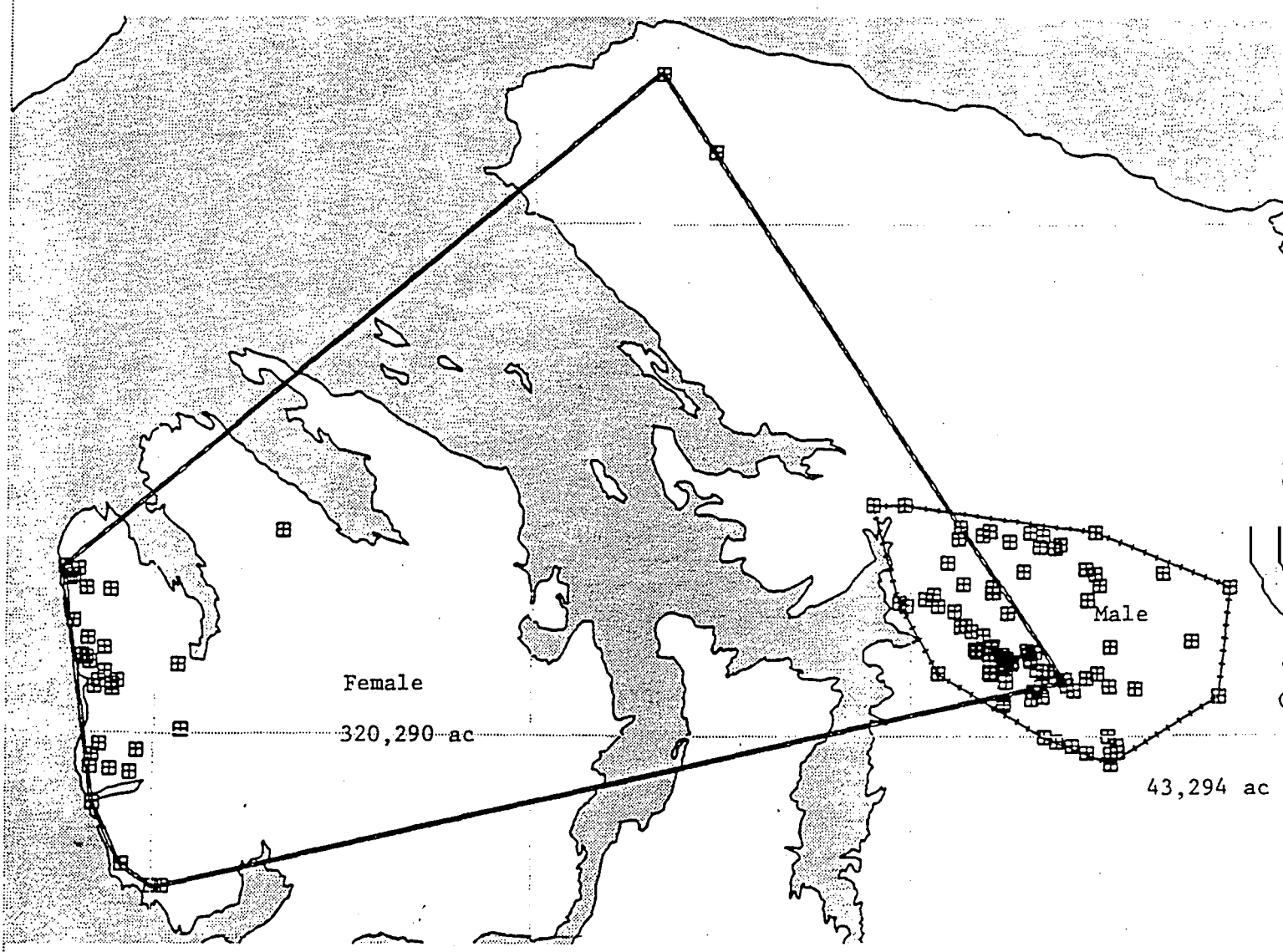

Total = 320,892 ac

MAPSCALE 1:298575

BJF1

3 0 3 6 9 12 Miles


Female
275,290 ac
Male
21,038 ac
N
MAPSCALE 1:347984
3 0 3 6 9 12 Miles

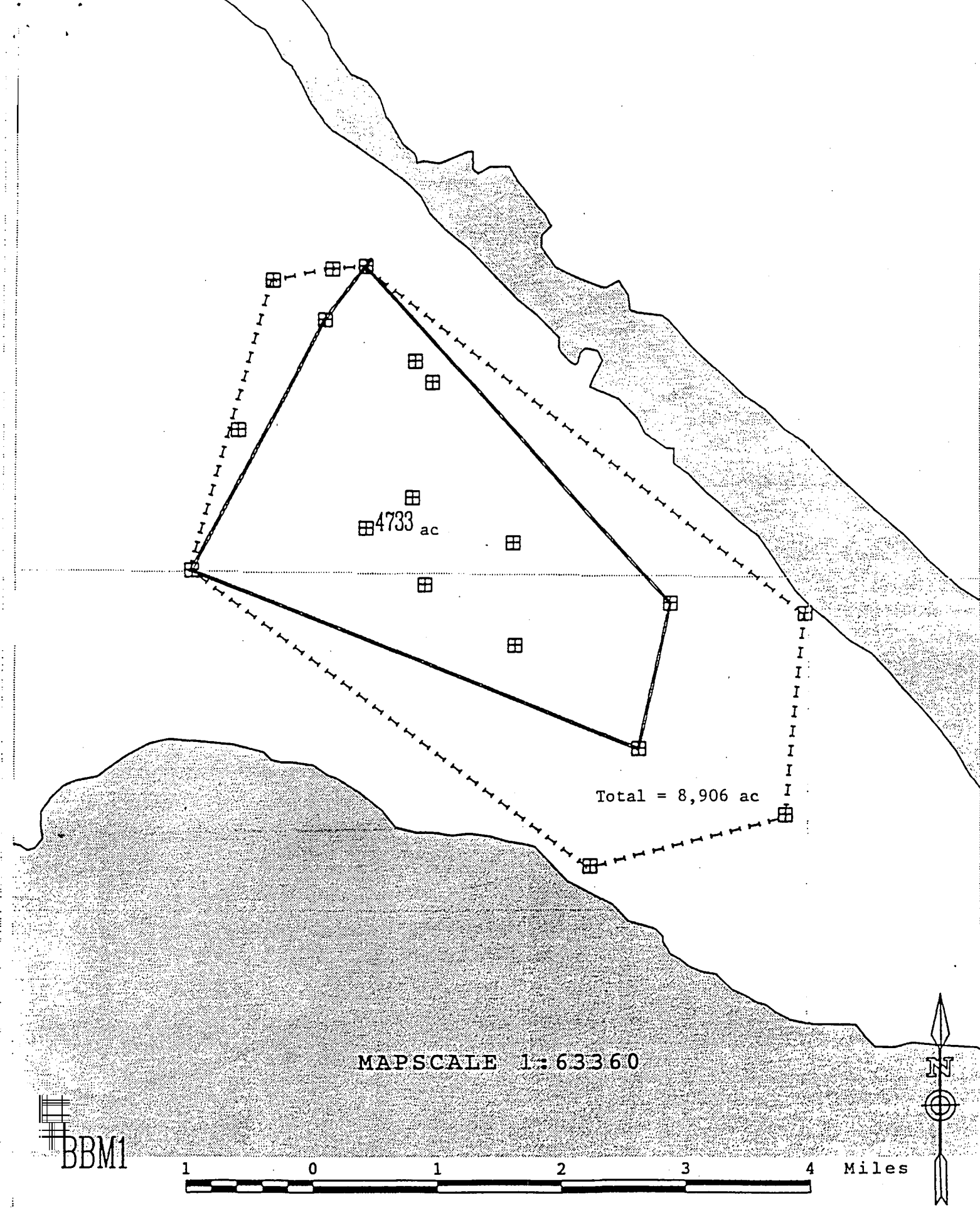


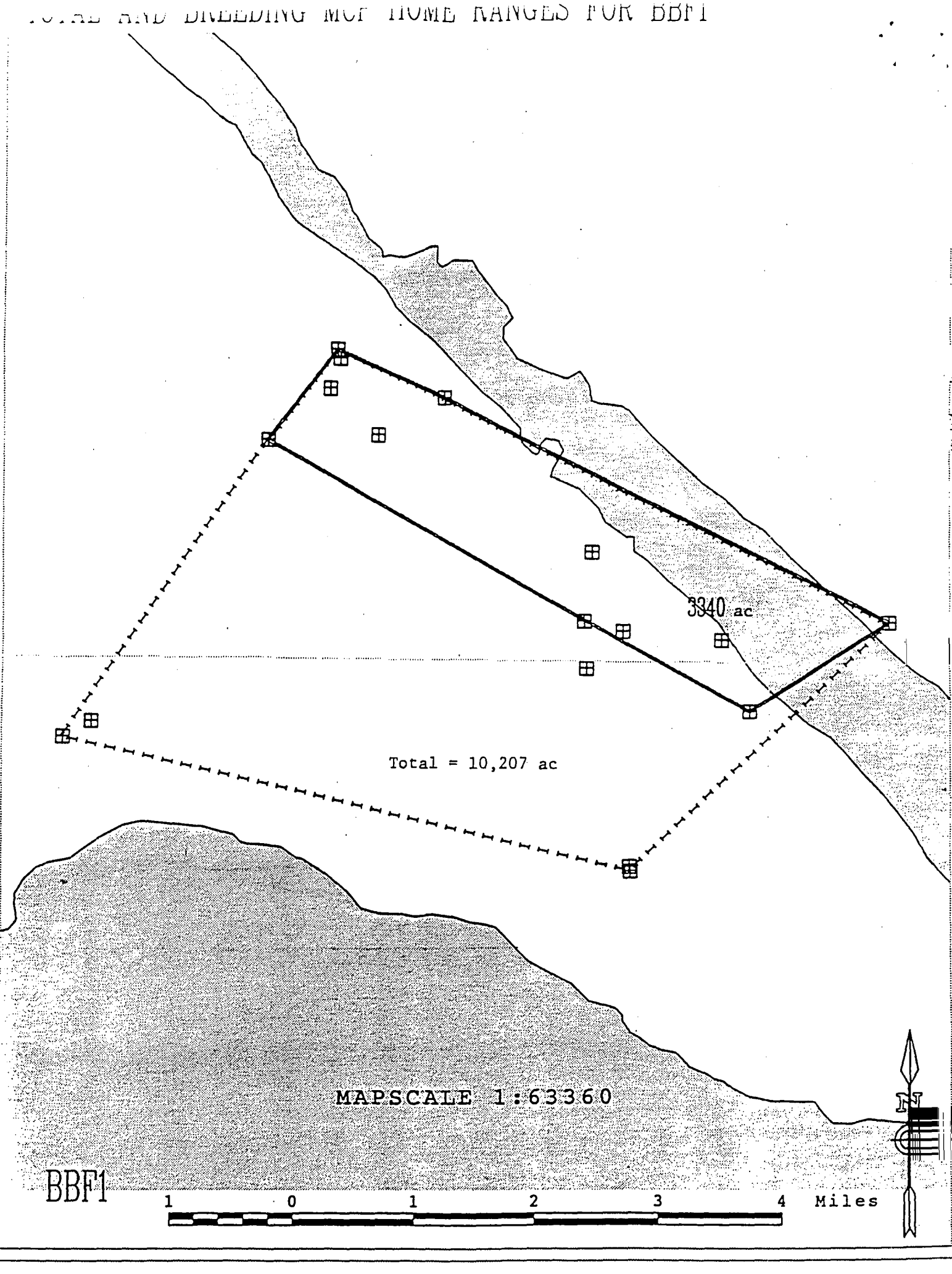

BJ

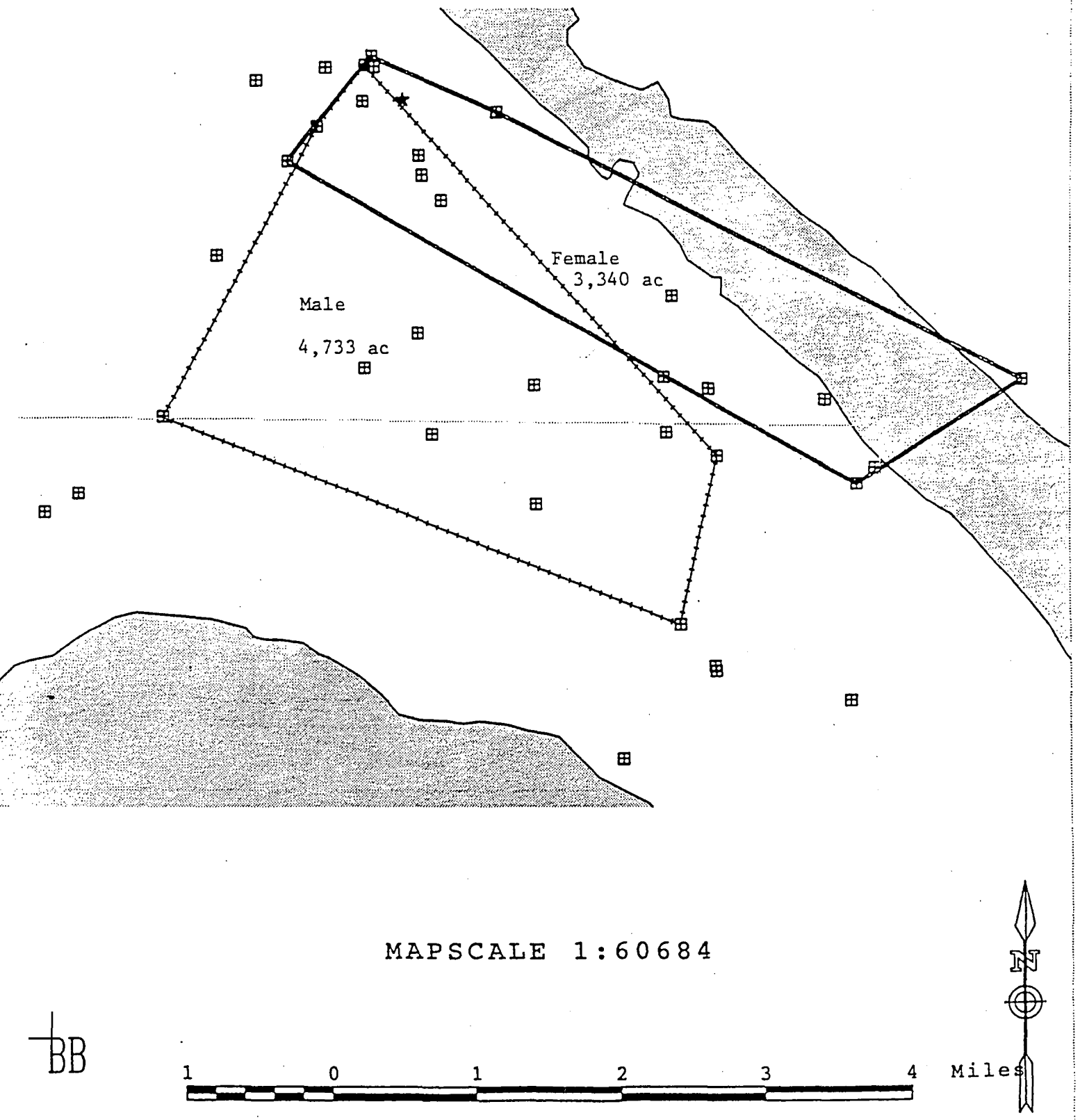
MAPSCALE 1:347984

3 0 3 6 9 12 Miles

N


4733 ac
Total = 8,906 ac
MAPSCALE 1:63360
BBM1
1 0 1 2 3 4 Miles
N


3340 ac
Total = 10,207 ac
MAPSCALE 1:63360
BBF1
1 0 1 2 3 4 Miles



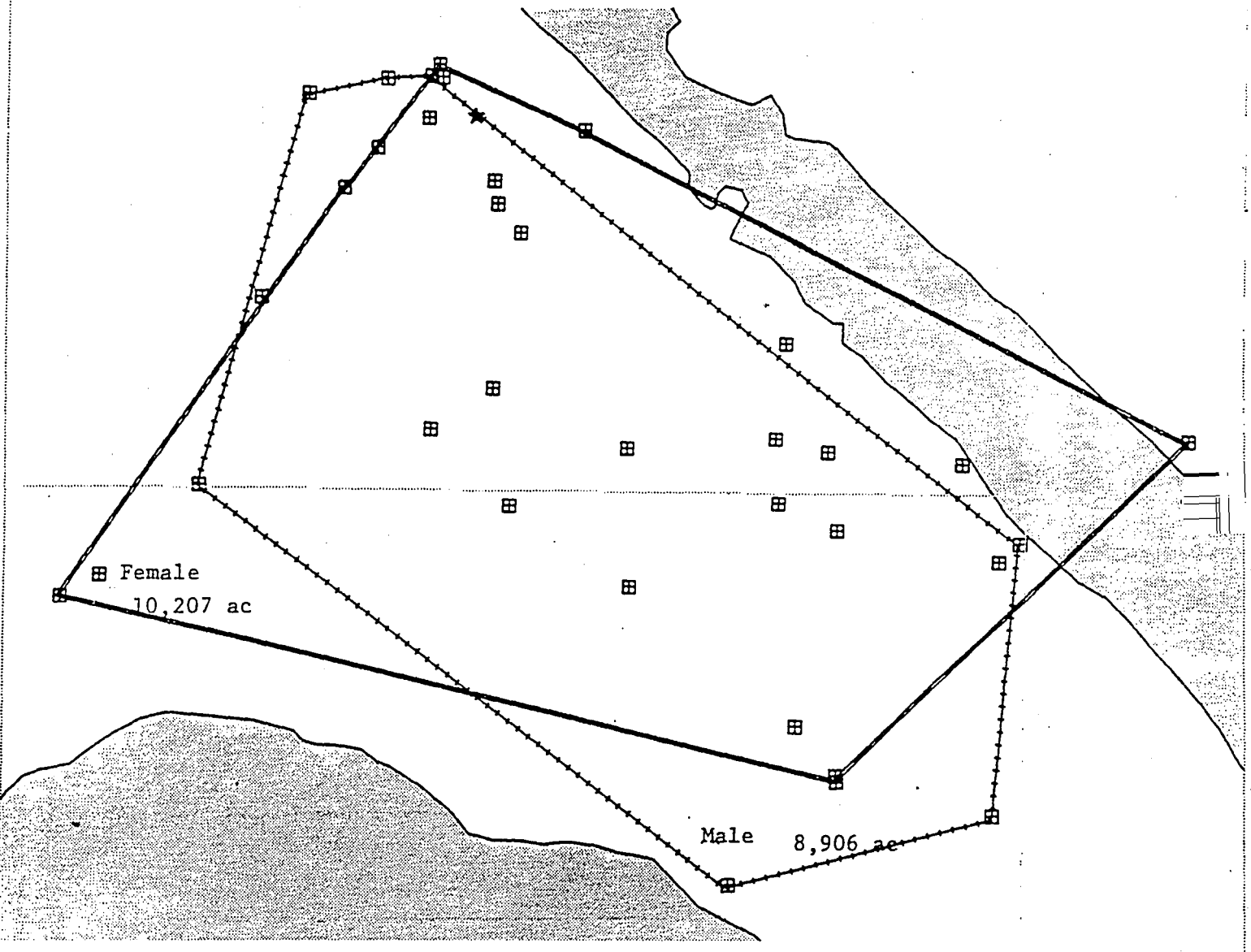

MAPSCALE 1:60684

BB

1 0 1 2 3 4 Miles

N

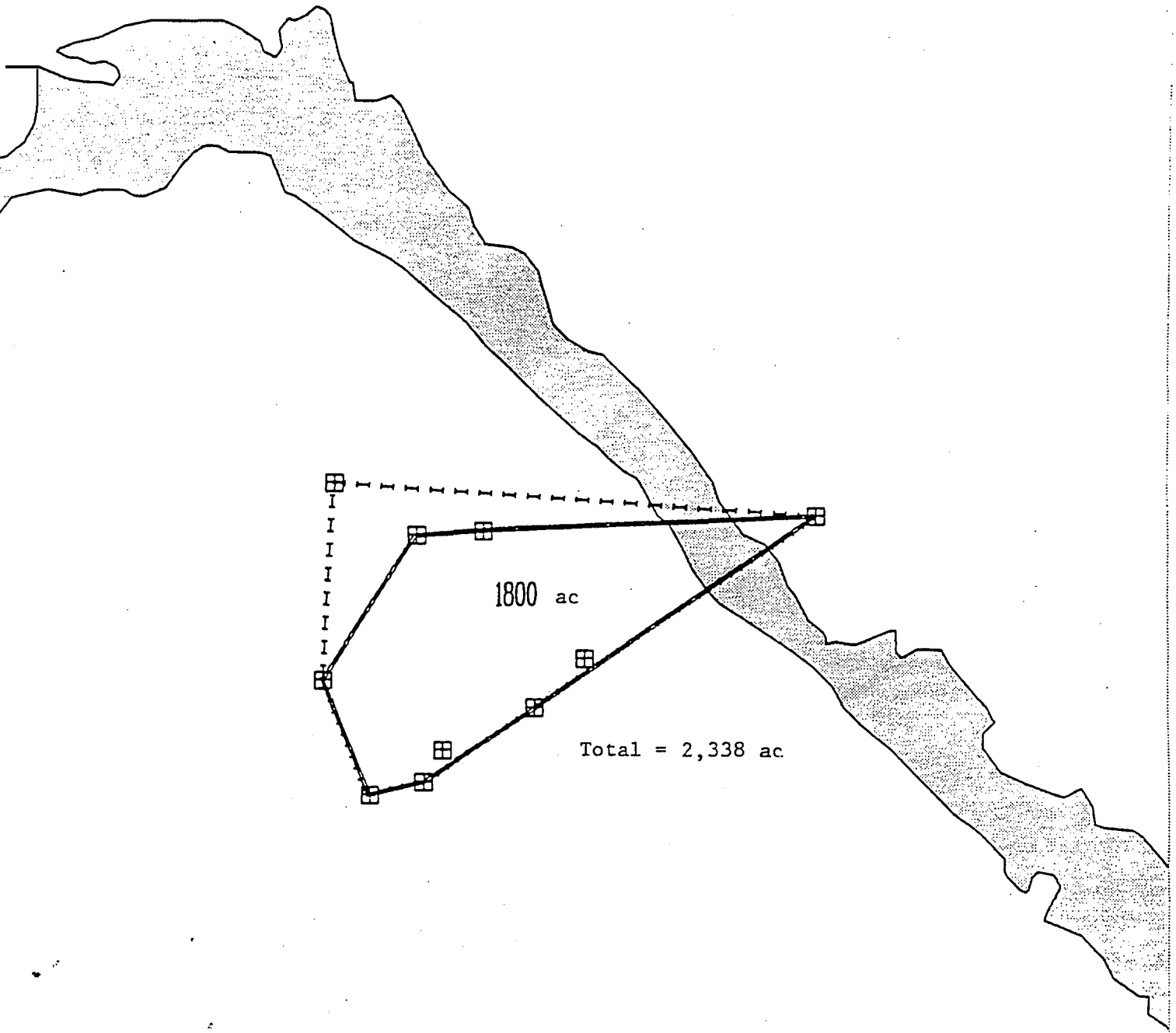
MCP TOTAL HOME RANGES FOR PAIR BB




MAPSCALE 1:60684

BB

1 0 1 2 3 4 Miles



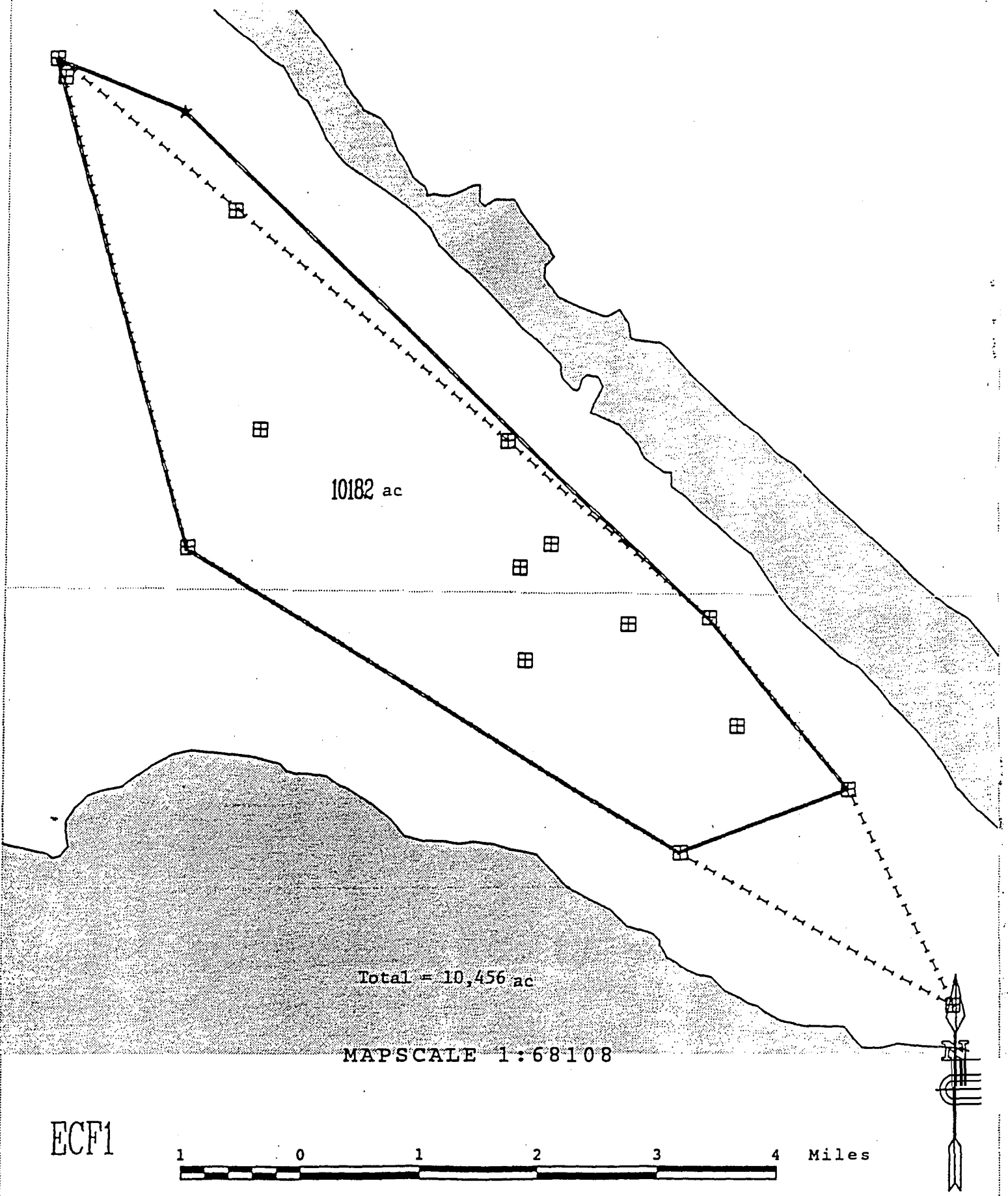

MAPSCALE 1:63360

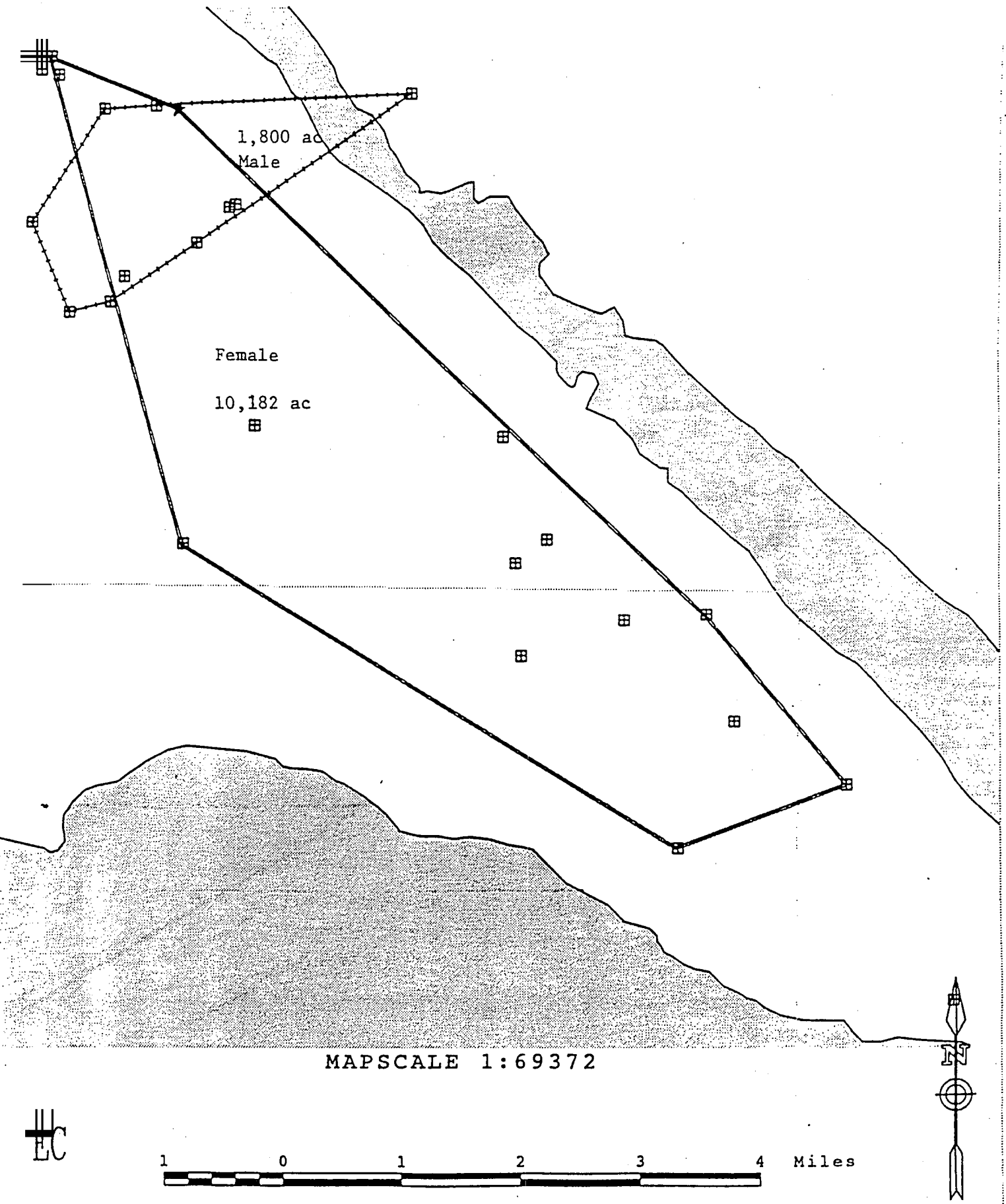
LCM1

1 0 1 2 3 4 Miles

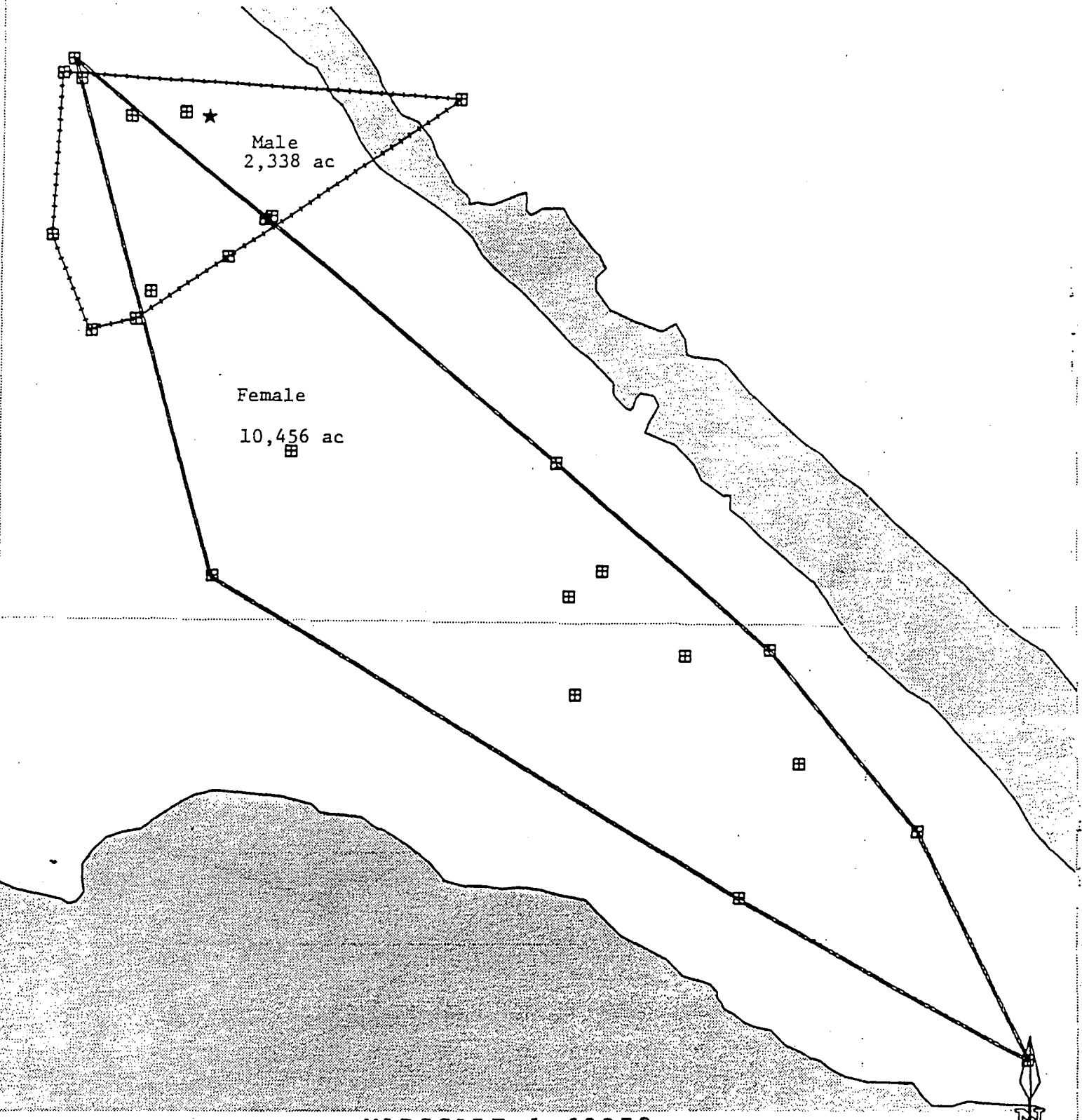
N

TOTAL AND BREEDING MCP HOME RANGES FOR ECF1




1,800 ac
Male
Female
10,182 ac
MAPSCALE 1:69372
N
EC
1 0 1 2 3 4 Miles

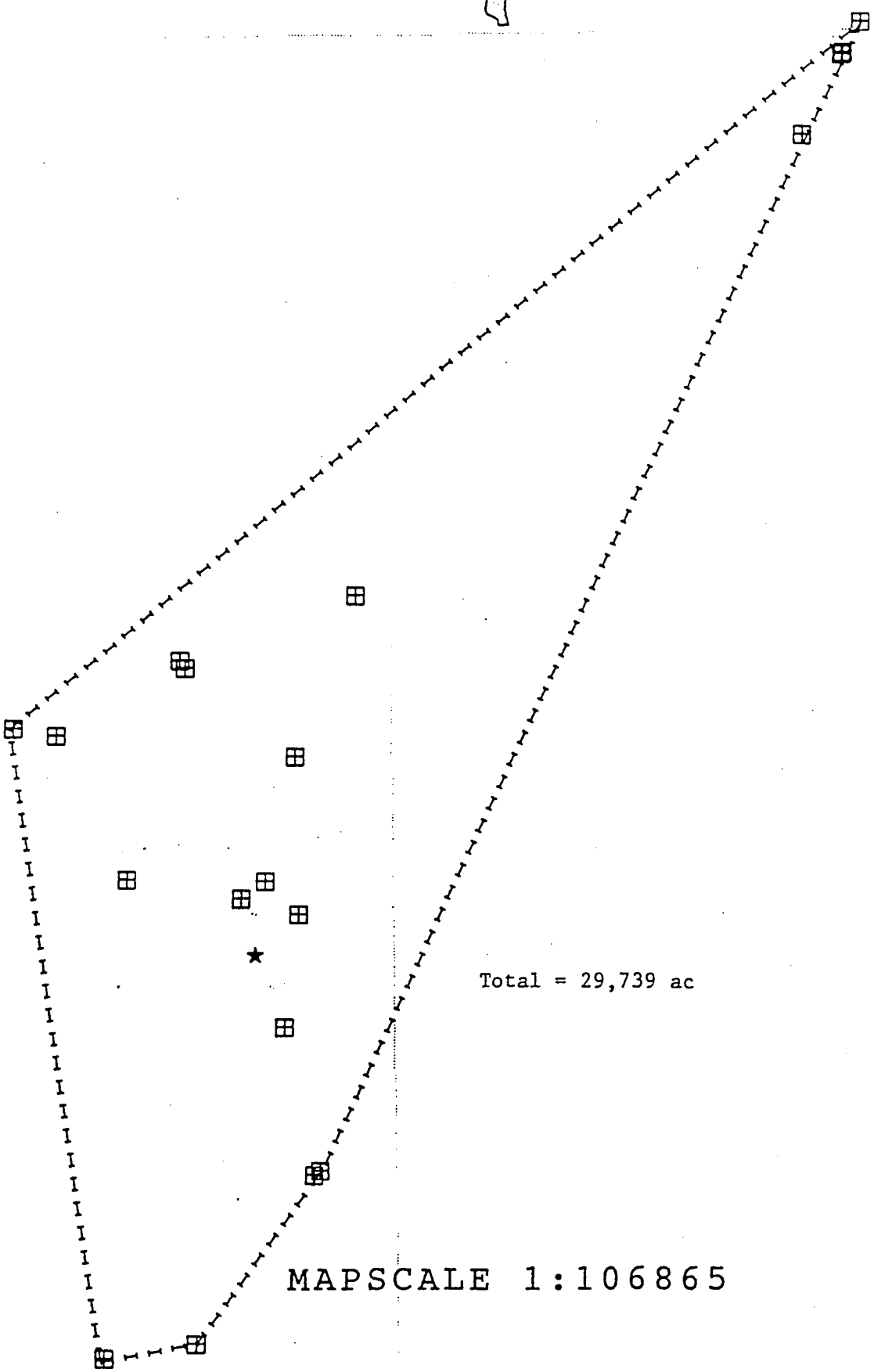
MCP TOTAL HOME RANGES FOR PAIR EC



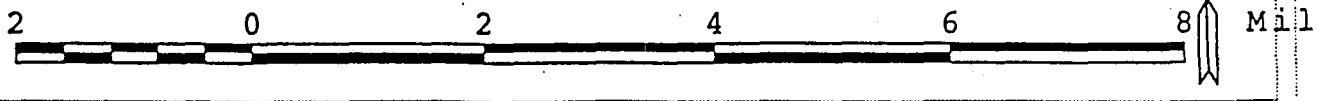

MAPSCALE 1:69372

EC

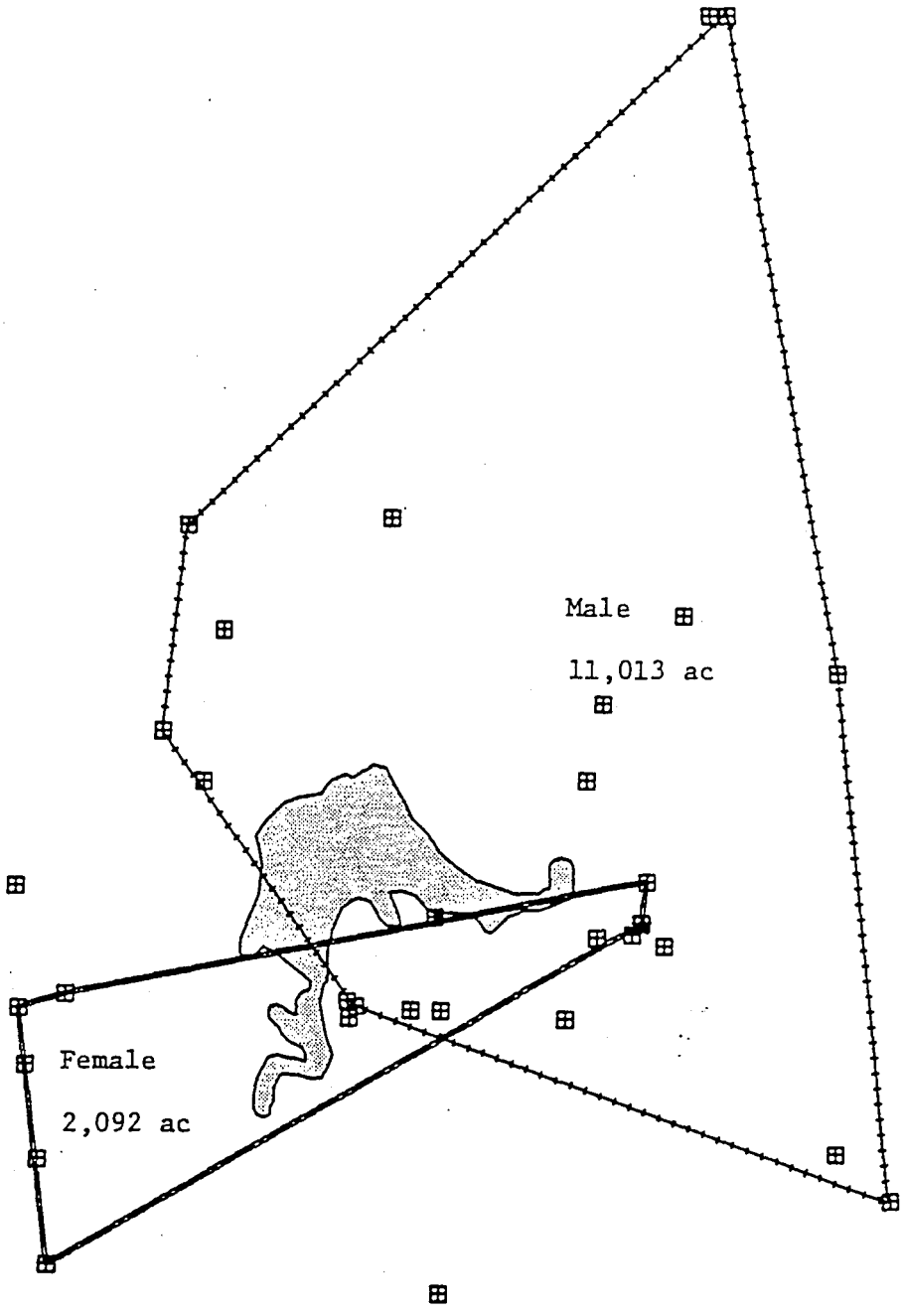
1 0 1 2 3 4 Miles




MAPSCALE 1:106865



MCP BREEDING HOME RANGES FOR PAIR NC .

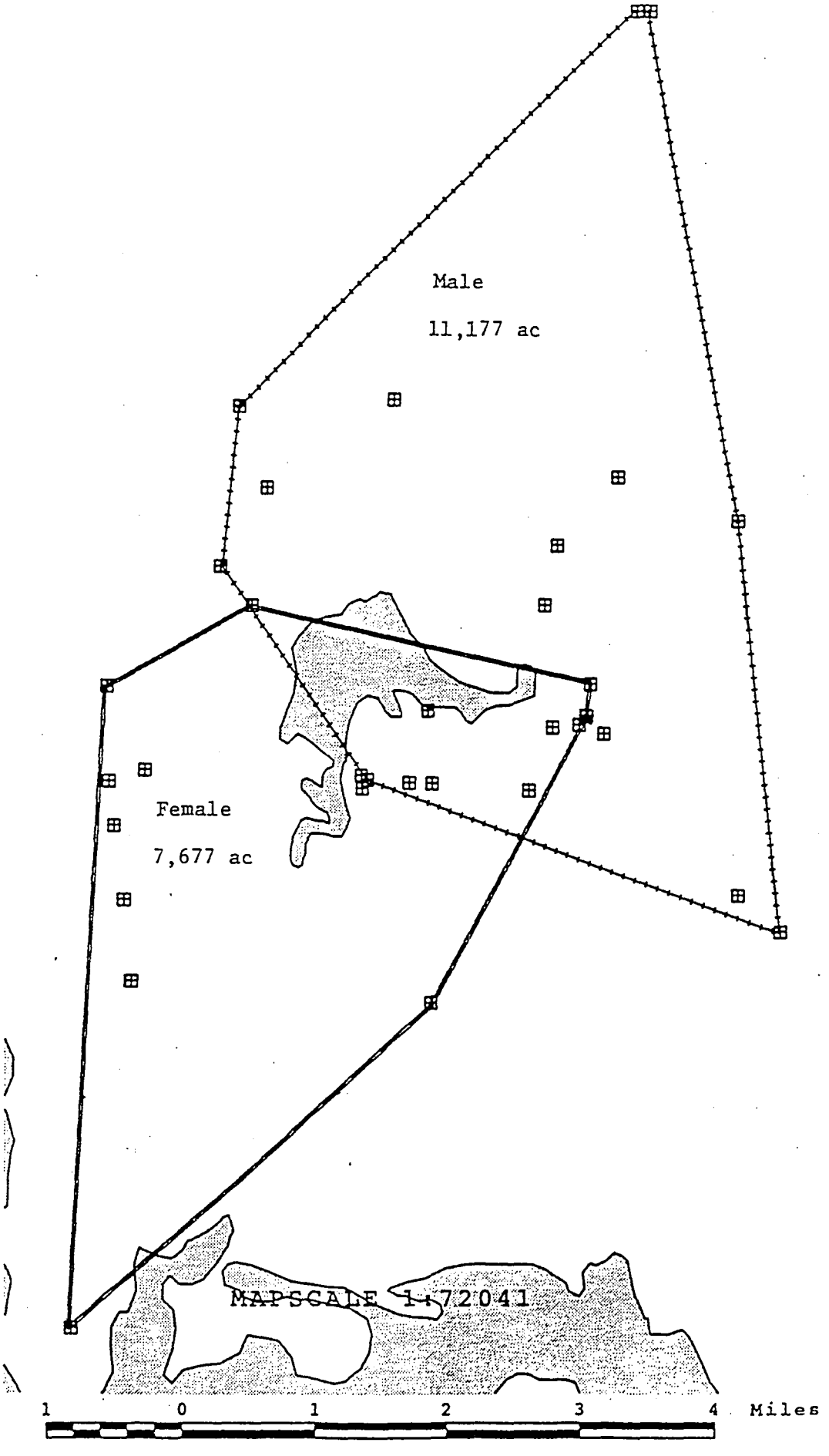



MAPSCALE 1:72041

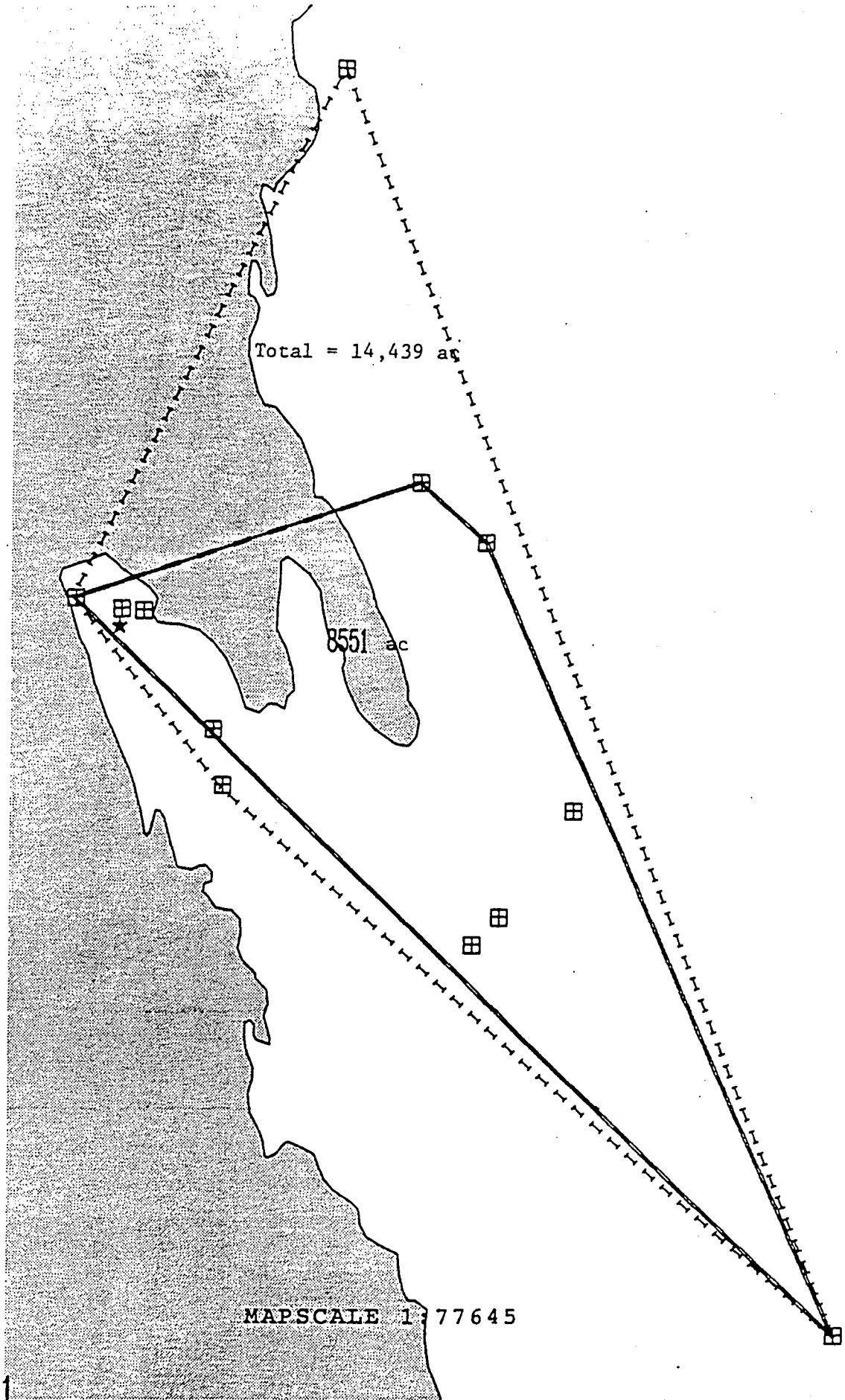
1 0 1 2 3 4 Miles

N

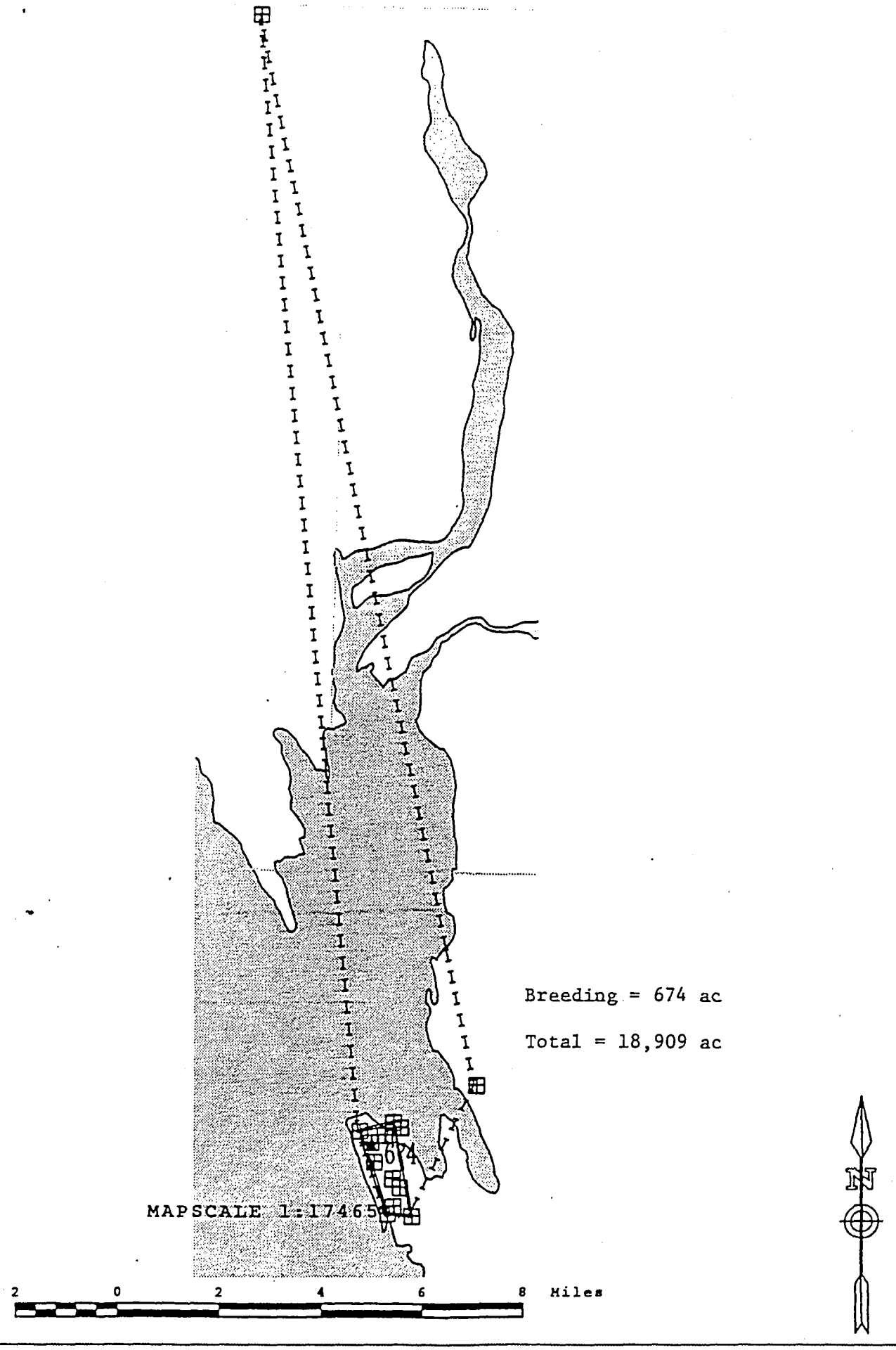
NC


Male
11,177 ac
Female
7,677 ac
MAPSCALE 1:72041
1 0 1 2 3 4 Miles
N

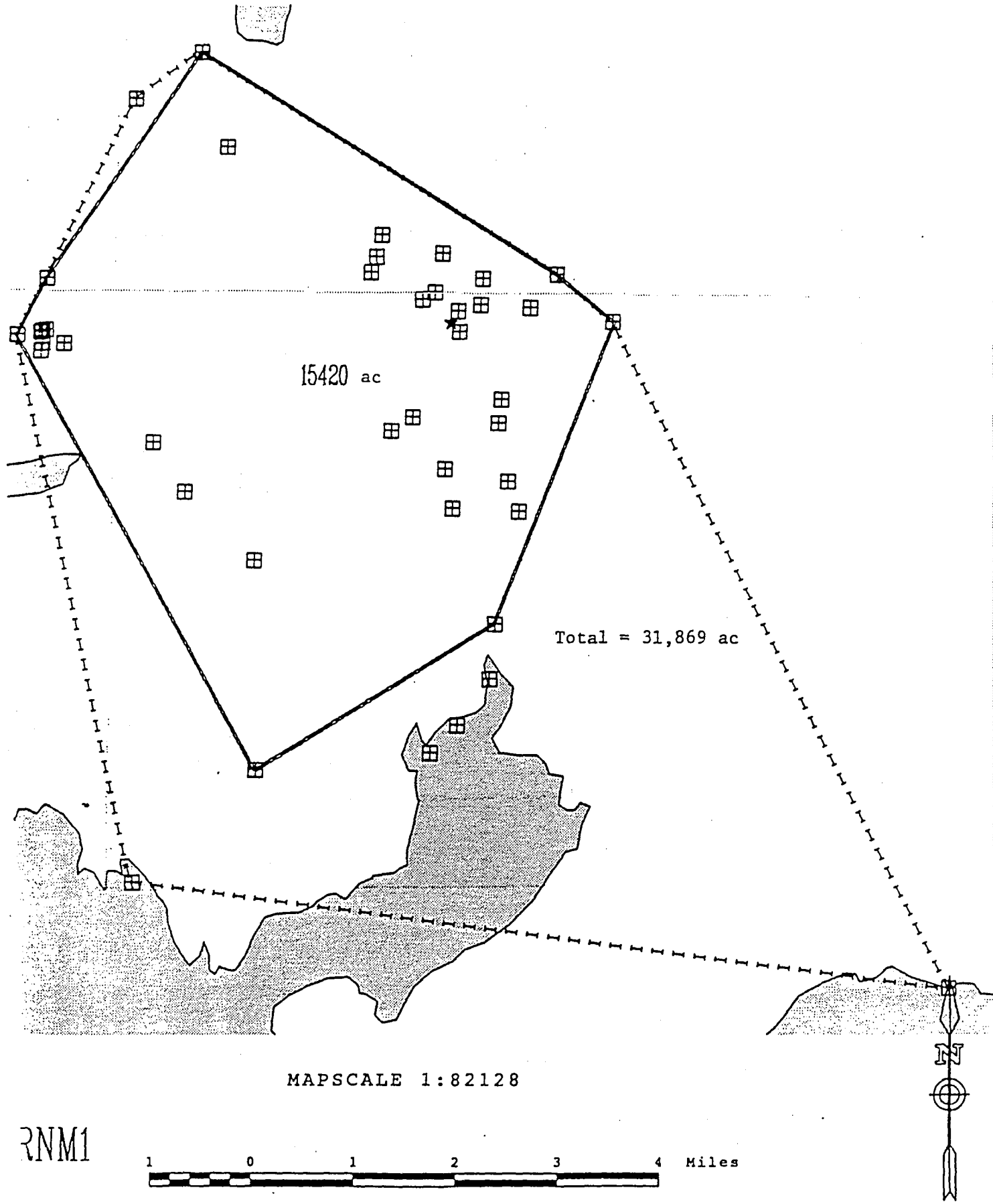
TOTAL AND BREEDING MCP HOME RANGES FOR PBM1



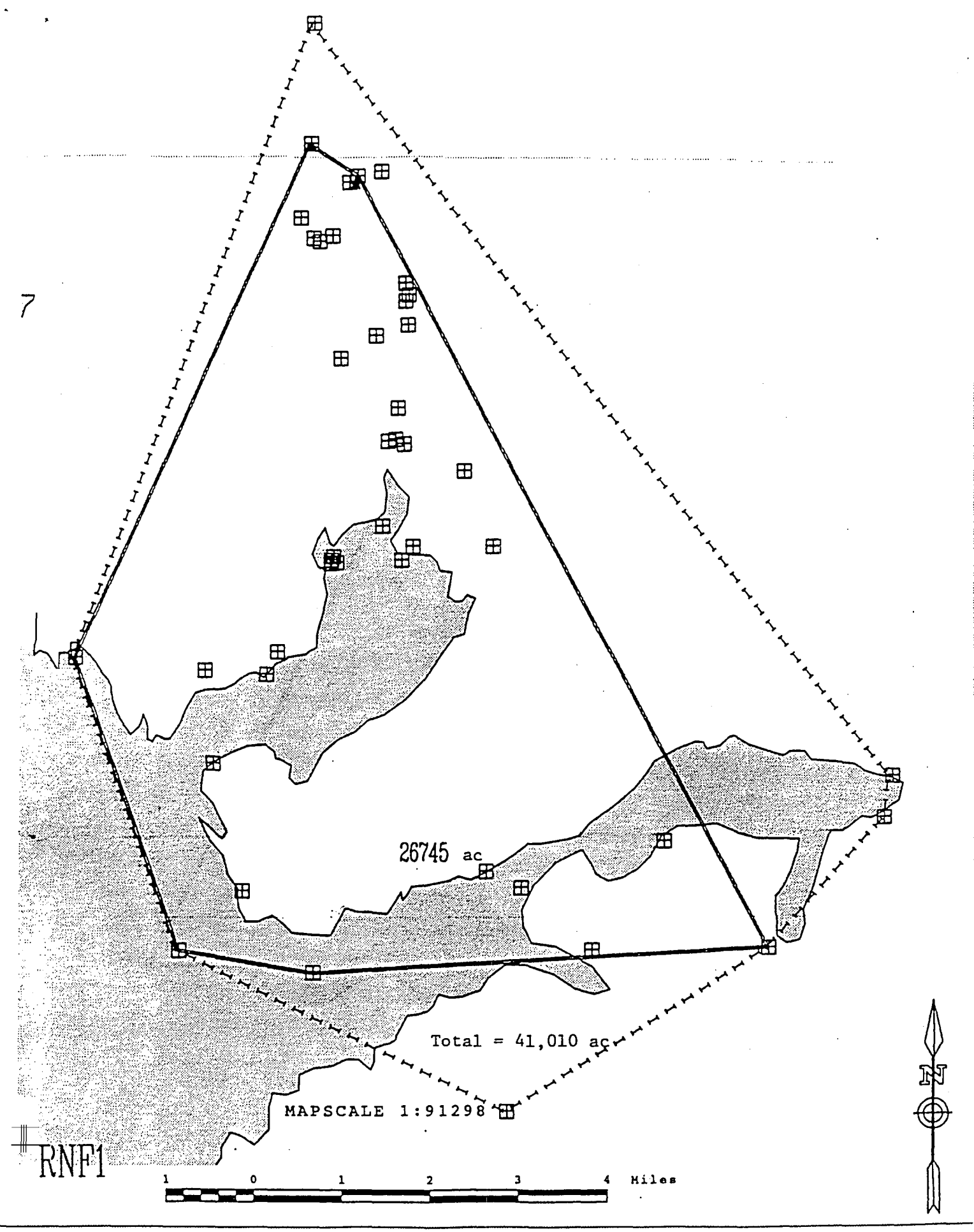

PBM1


Breeding = 674 ac
Total = 18,909 ac
MAPSCALE 1:17465
2 0 2 4 6 8 Miles
N

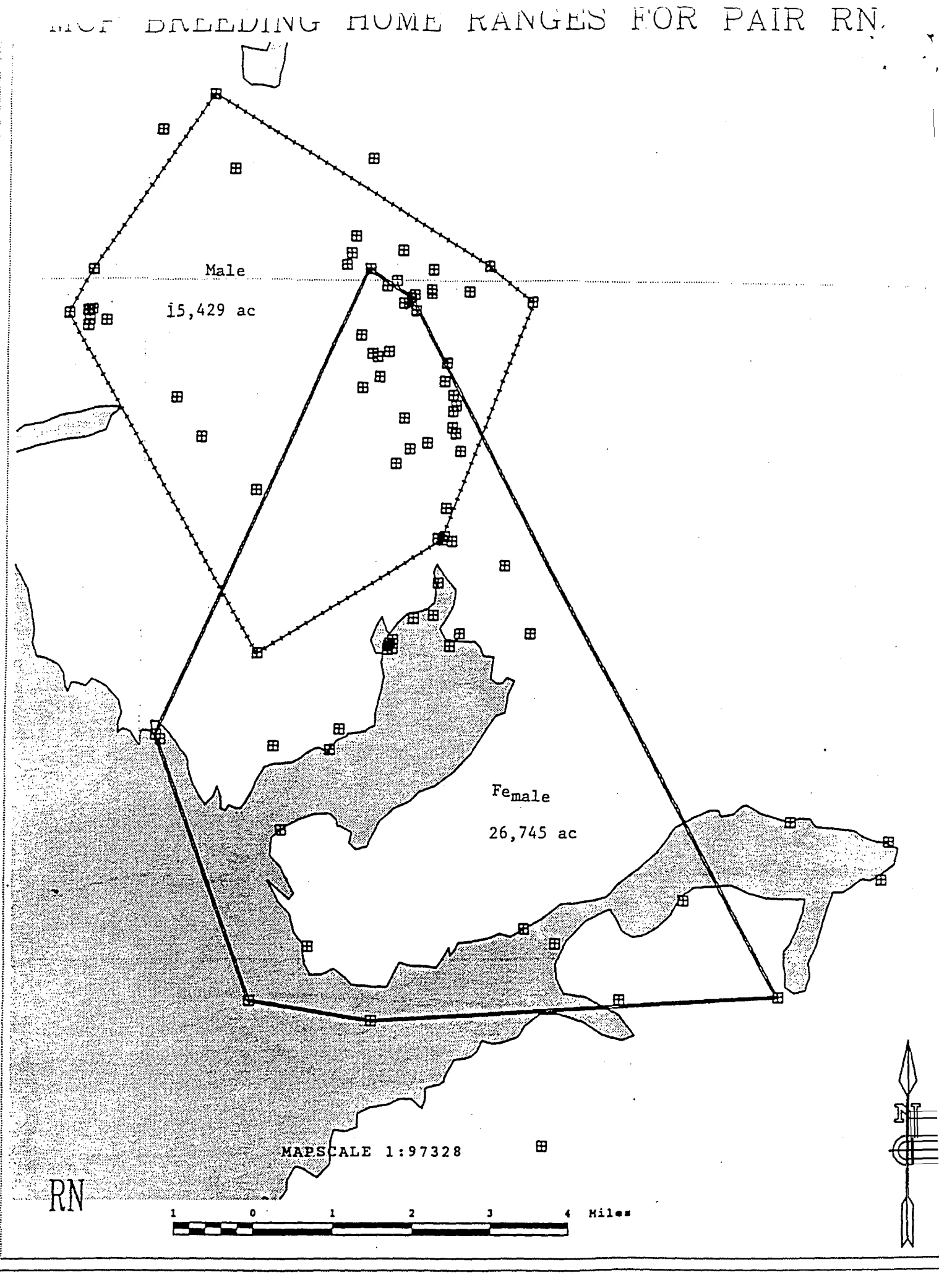
TOTAL AND BREEDING MCP HOME RANGES FOR RNM1

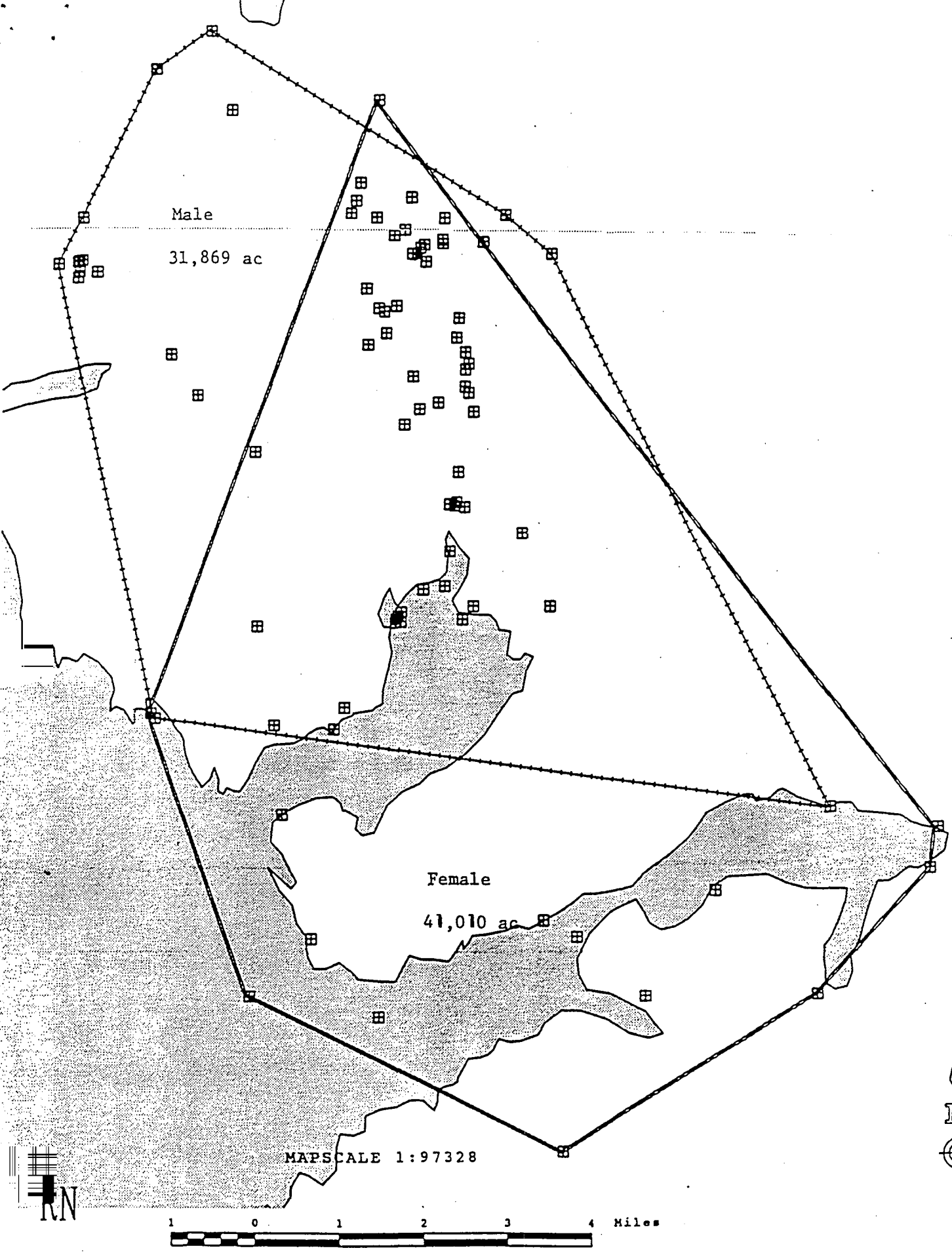



RNM1

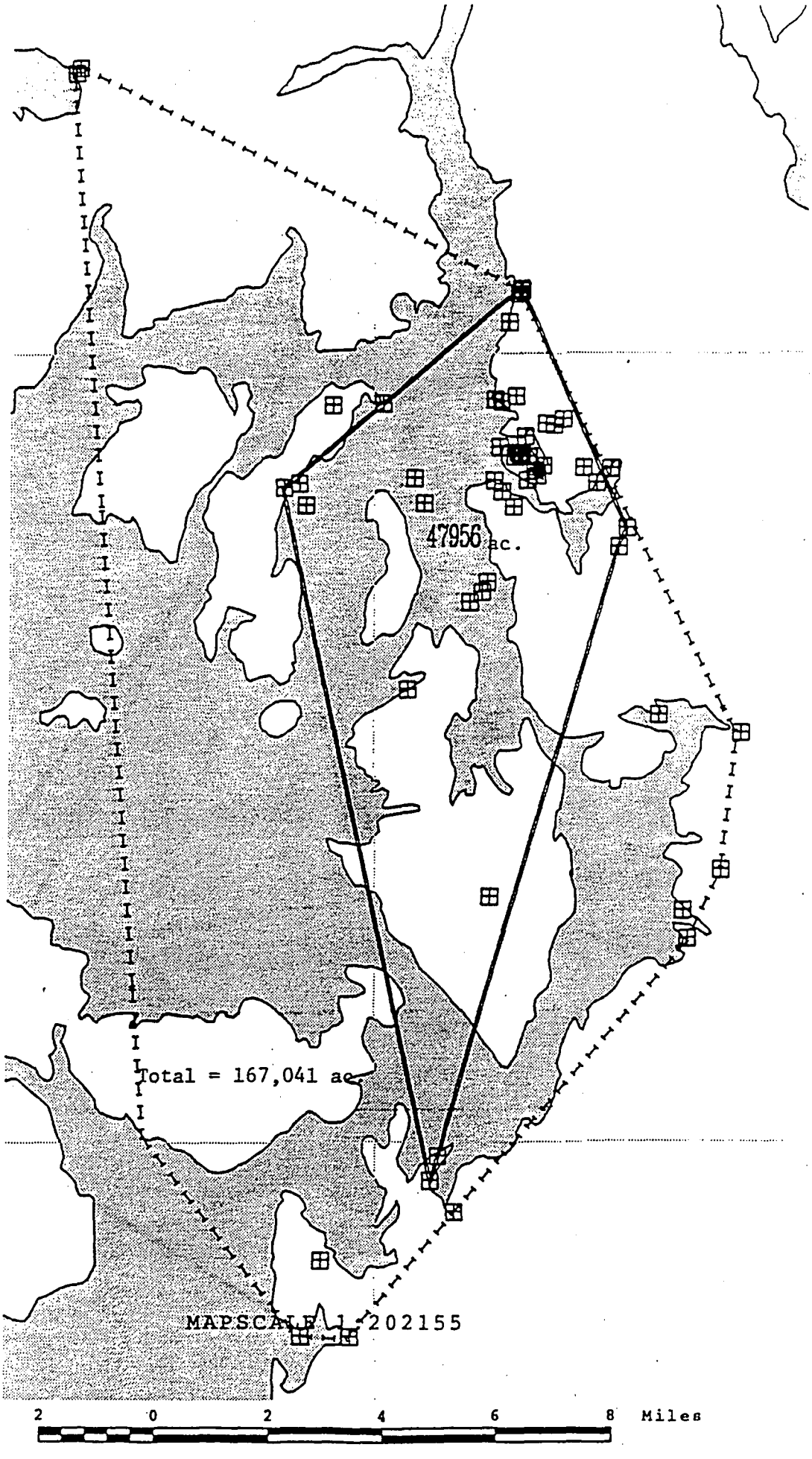

7
26745 ac
Total = 41,010 ac
MAPSCALE 1:91298
RNF1
1 0 1 2 3 4 Miles
N

# MCP BREEDING HOME RANGES FOR PAIR RN.

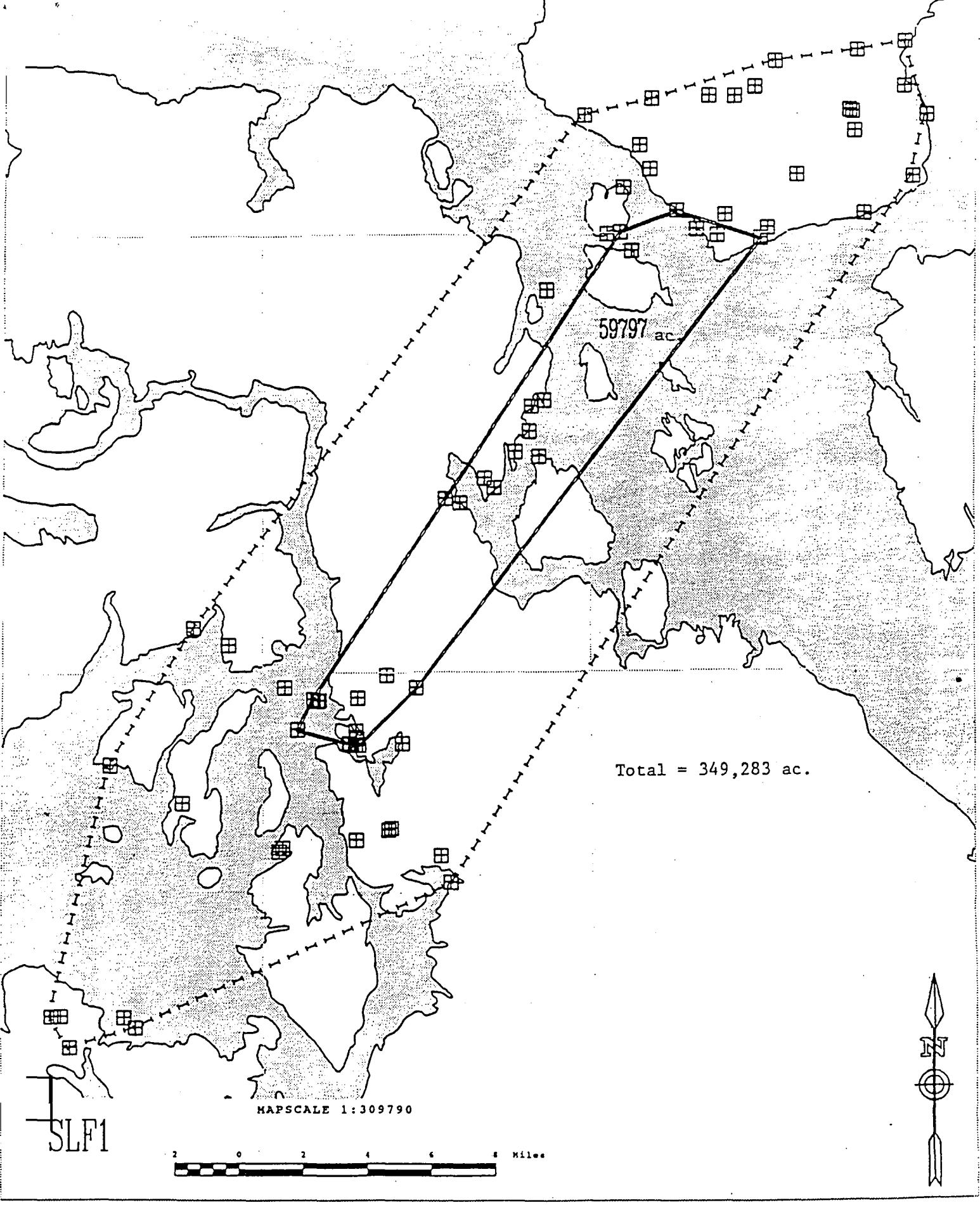



Male
31,869 ac
Female
41,010 ac
MAPSCALE 1:97328
1 0 1 2 3 4 Miles
N

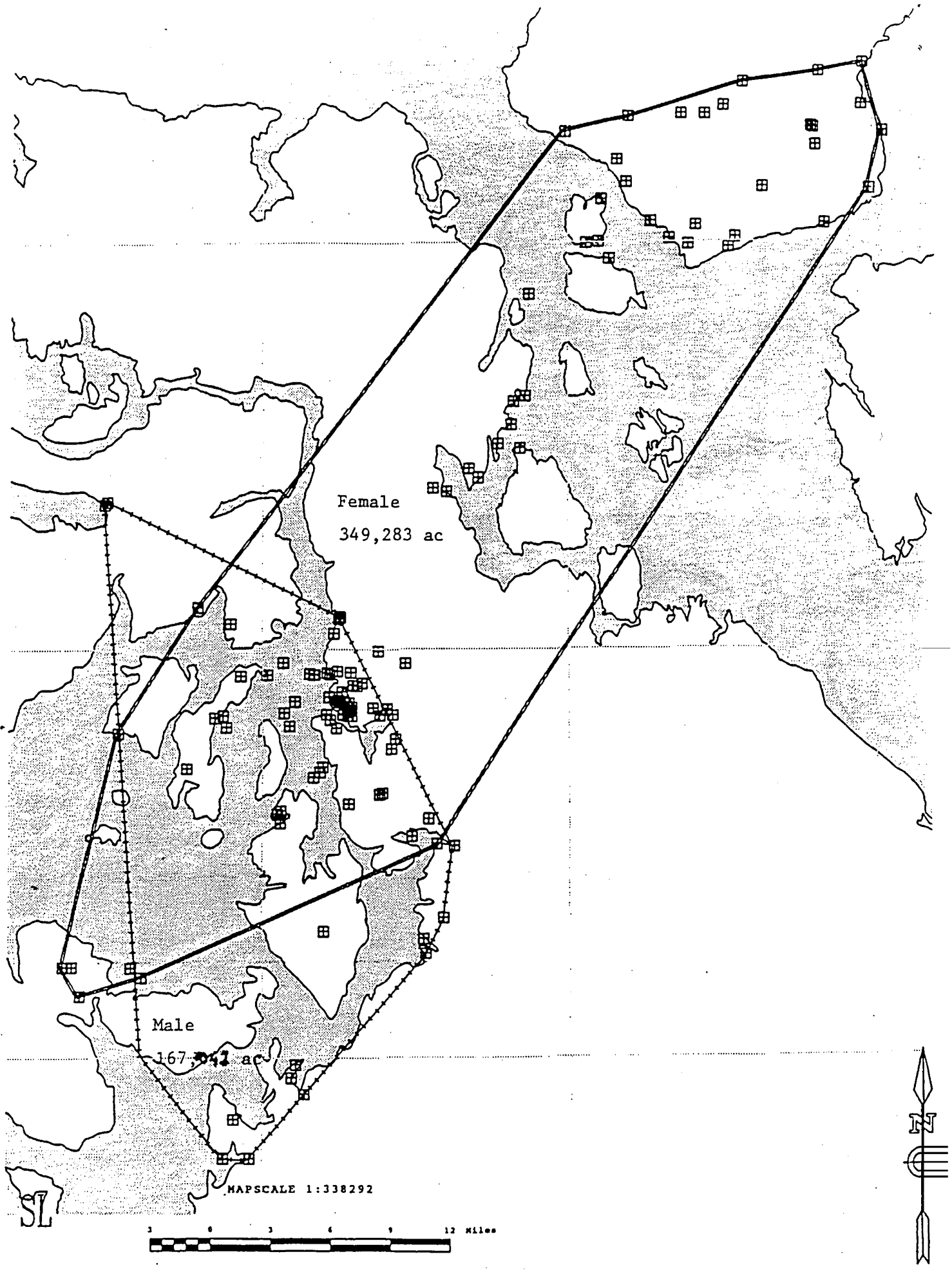
TOTAL AND BREEDING MCP HOME RANGES FOR SLM1

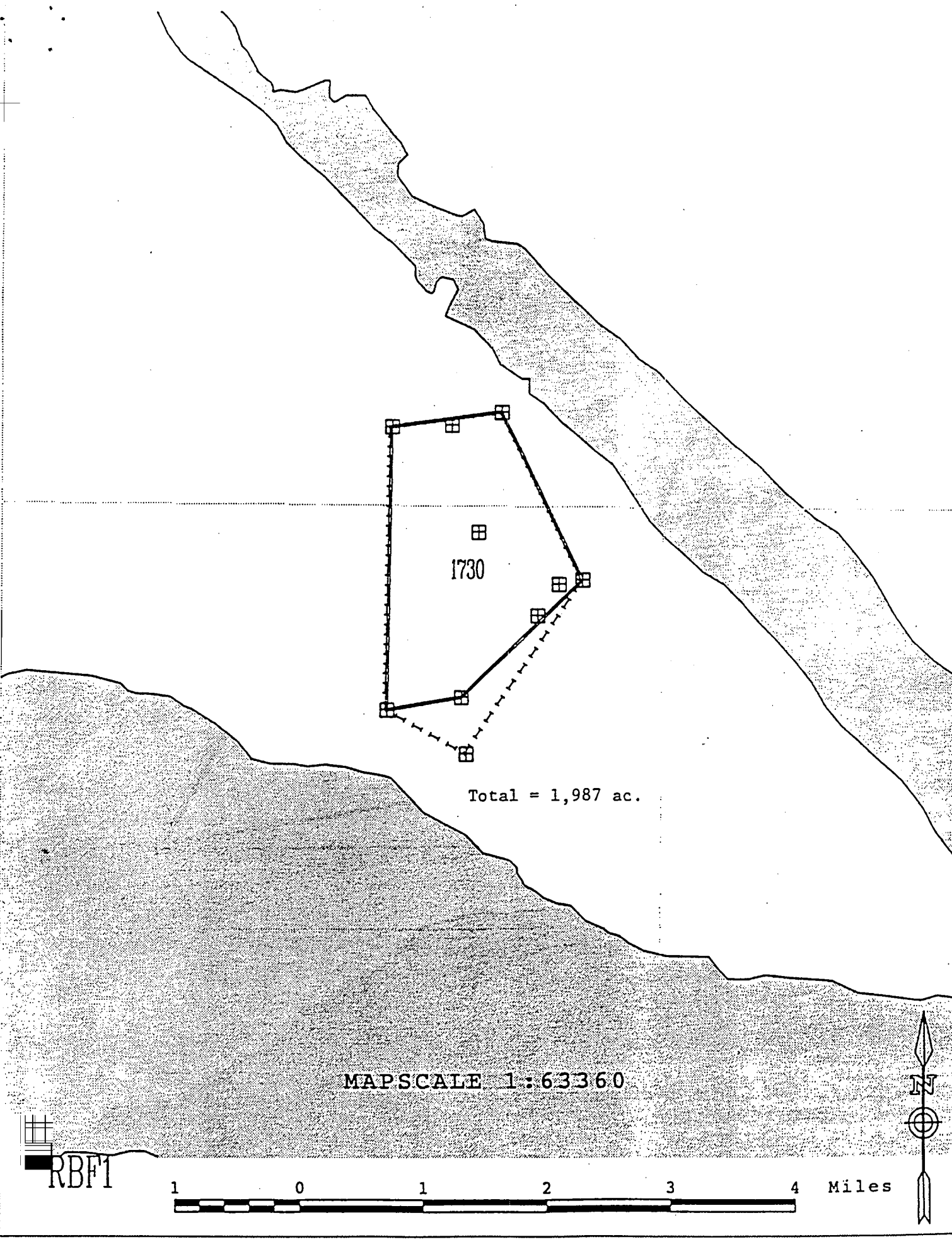



SLM1

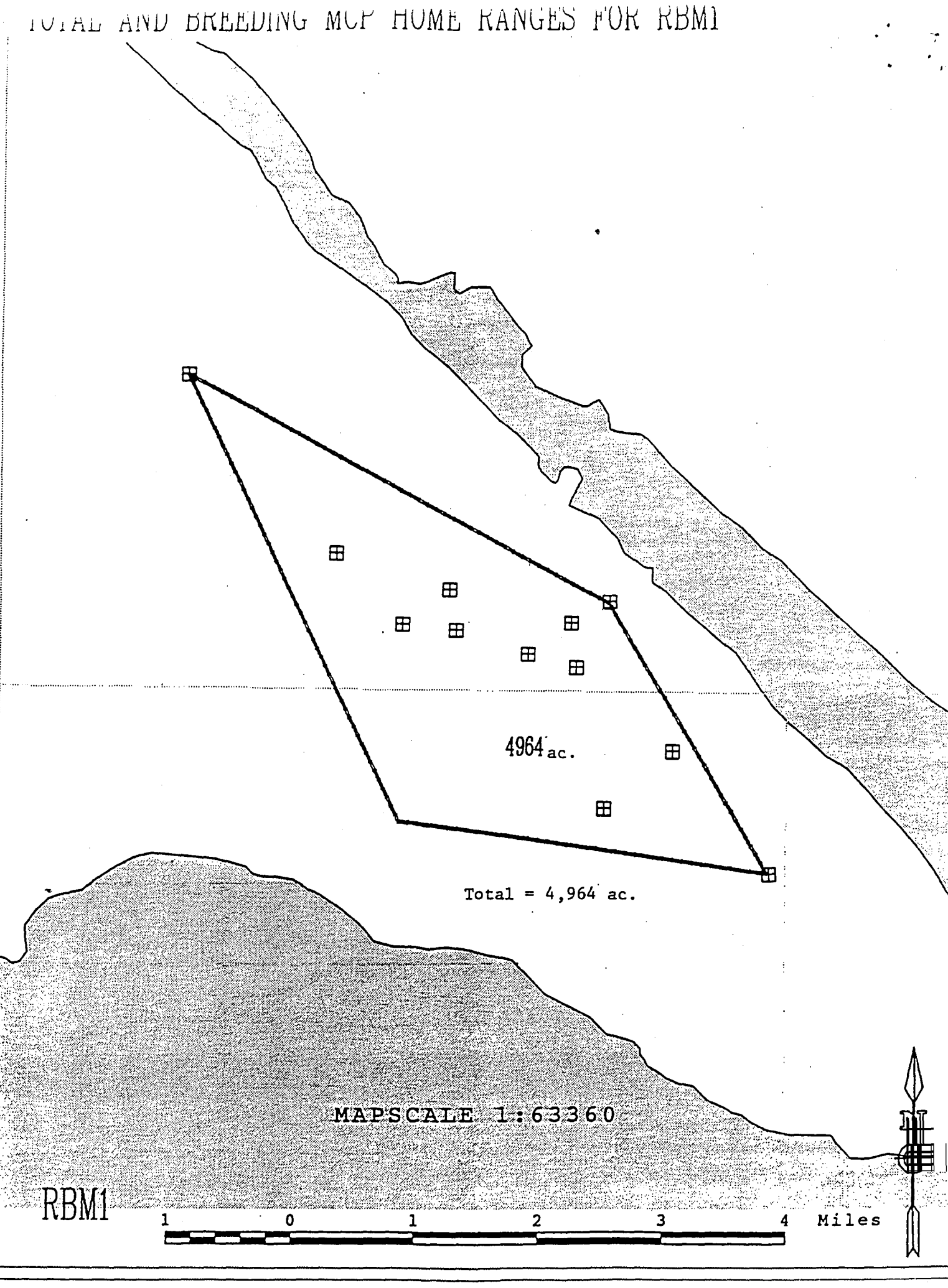

59797 ac.
Total = 349,283 ac.
MAPSCALE 1:309790
SLF1
N
2 0 2 4 6 8 Miles

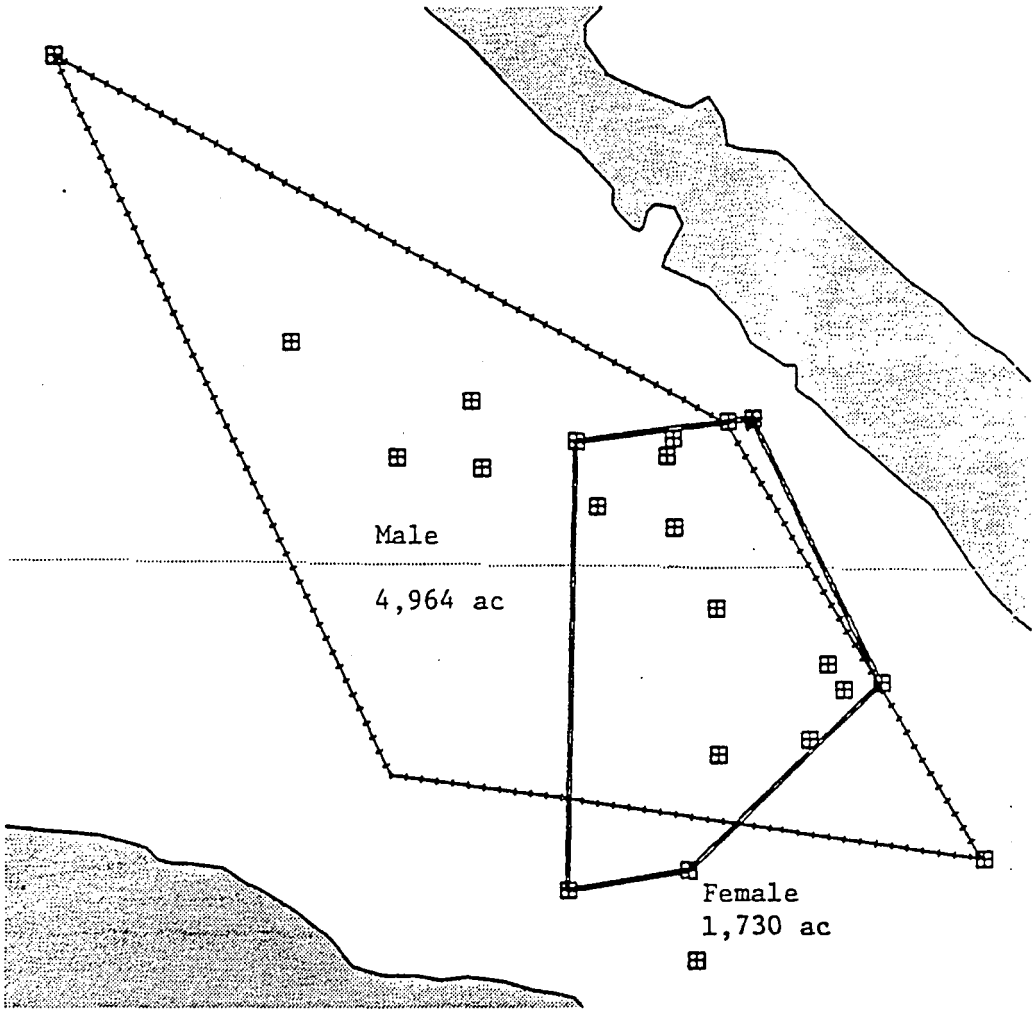
MCP TOTAL HOME RANGES FOR PAIR SL




1730
Total = 1,987 ac.
MAPSCALE 1:63360
N
RBF1
1 0 1 2 3 4 Miles

TOTAL AND BREEDING MCP HOME RANGES FOR RBM1





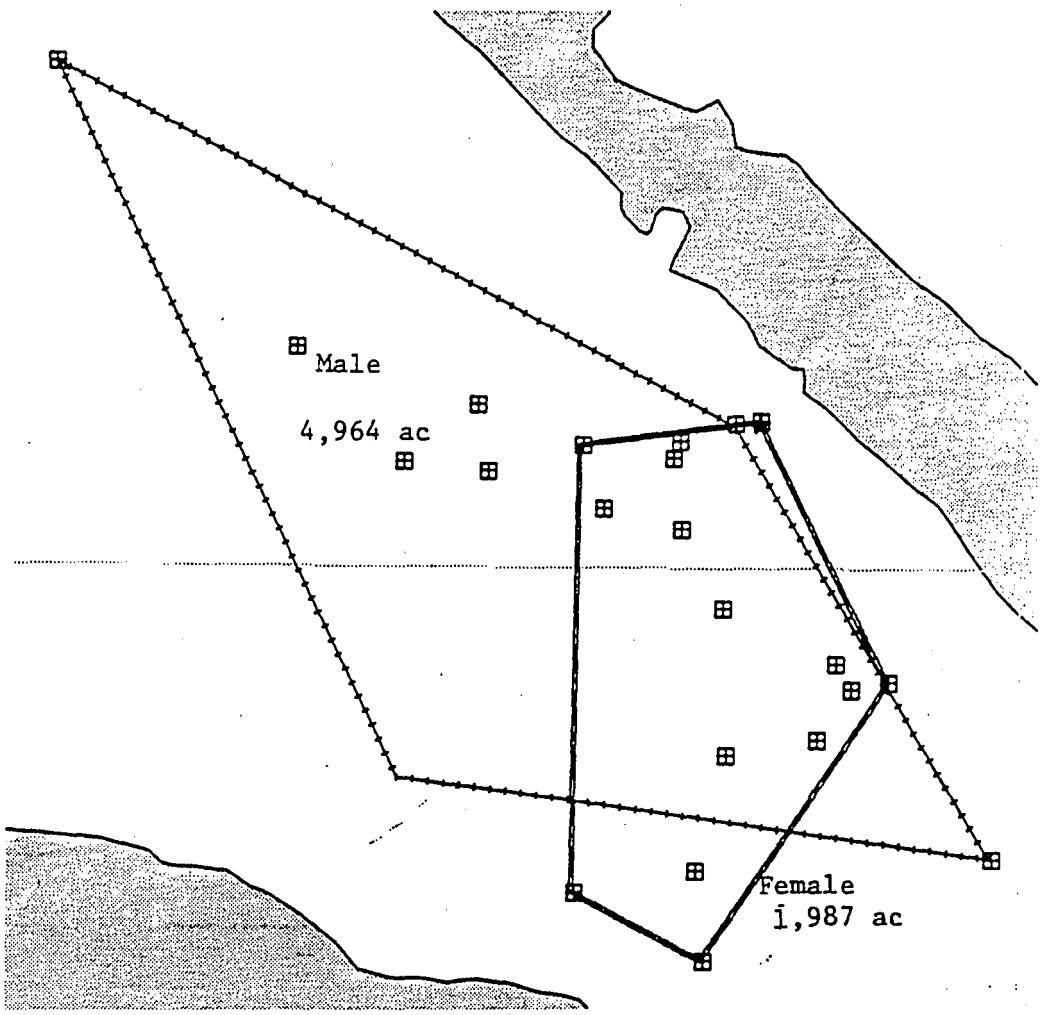

MAPSCALE 1:63360

RB

1 0 1 2 3 4 Miles

N

# MCP TOTAL HOME RANGES FOR PAIR RB




MAPSCALE 1:63360

RB

1 0 1 2 3 4 Miles

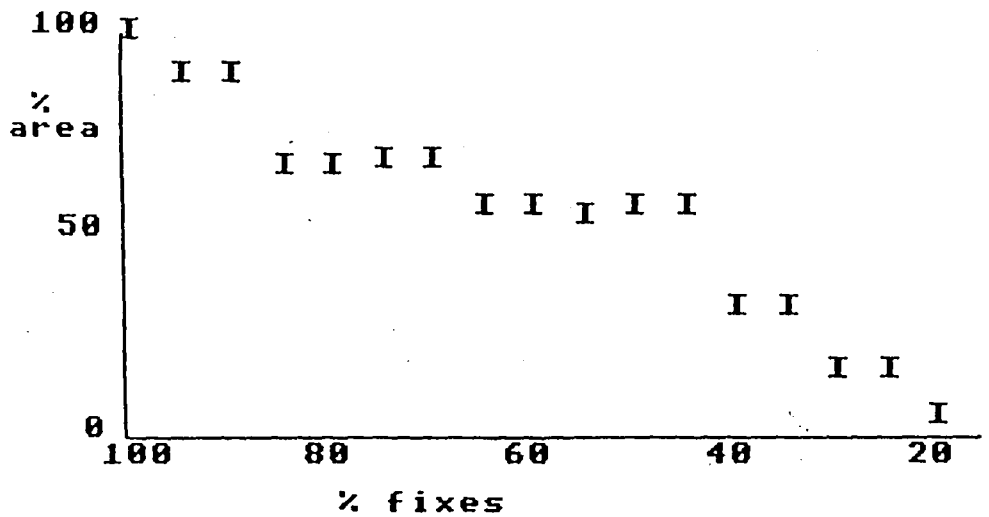
N

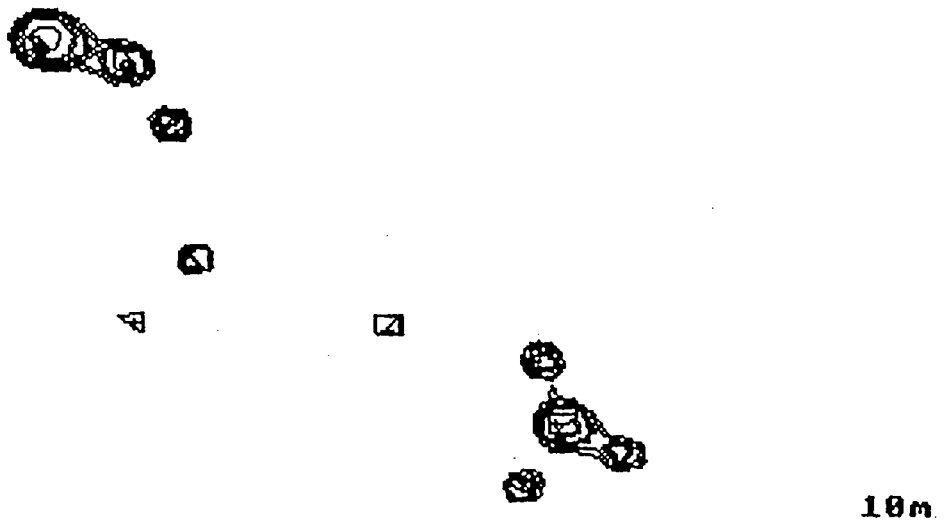
Adult northern goshawk breeding harmonic mean (HM) home ranges at 5% isopleth
ectares) as determined by RANGES IV (Kenward 1990). With the exception of EC
which were radio-tagged during the fledgling dependency period, breeding home range
were based on radio-telemetry relocations from mid to late nestling period up until juvenile
sal.

ADULTFEMALE8 7/93 (N=11)
Isopleth Areas  Max = 1109.85 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 992.73 (89.45) | 55 | 605.44 (54.55) |
| 90 | 992.73 (89.45) | 50 | 632.30 (56.97) |
| 85 | 744.73 (67.10) | 45 | 632.30 (56.97) |
| 80 | 744.73 (67.10) | 40 | 352.69 (31.78) |
| 75 | 758.47 (68.34) | 35 | 352.69 (31.78) |
| 70 | 758.47 (68.34) | 30 | 181.82 (16.38) |
| 65 | 629.10 (56.68) | 25 | 181.82 (16.38) |
| 60 | 629.10 (56.68) | 20 | 60.48 (5.45) |

Eagle Creek adult female
Chatham Area



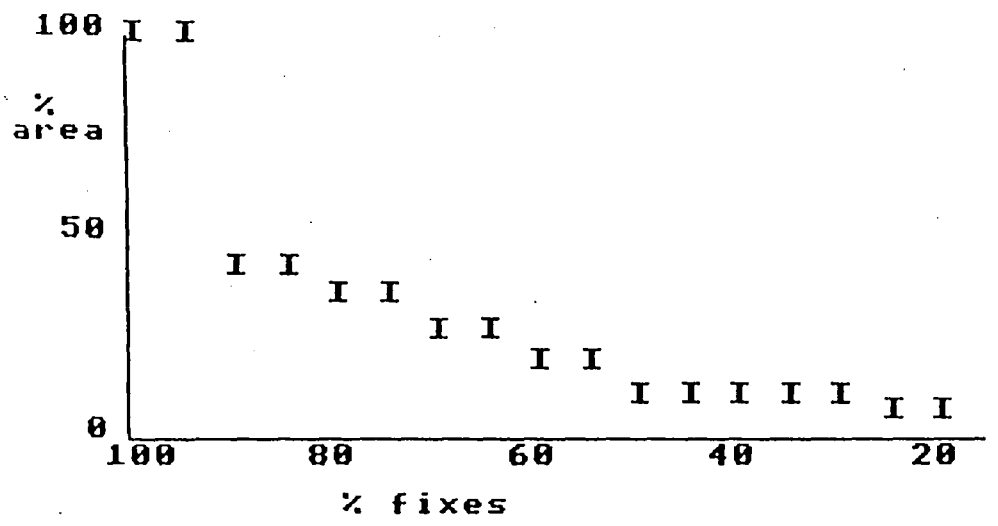




40,40

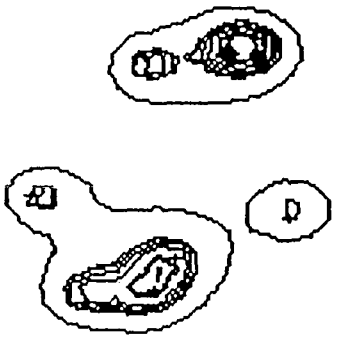
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE9 7/93 (N=9)
Isopleth Areas  Max = 415.60 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 415.60 (100.00) | 55 | 79.66 (19.17) |
| 90 | 177.20 (42.64) | 50 | 43.35 (10.43) |
| 85 | 177.20 (42.64) | 45 | 43.35 (10.43) |
| 80 | 149.11 (35.88) | 40 | 43.35 (10.43) |
| 75 | 149.11 (35.88) | 35 | 42.94 (10.33) |
| 70 | 110.10 (26.49) | 30 | 42.94 (10.33) |
| 65 | 110.10 (26.49) | 25 | 27.41 (6.60) |
| 60 | 79.66 (19.17) | 20 | 27.41 (6.60) |




Eagle Creek adult male
Chatham Area



10m

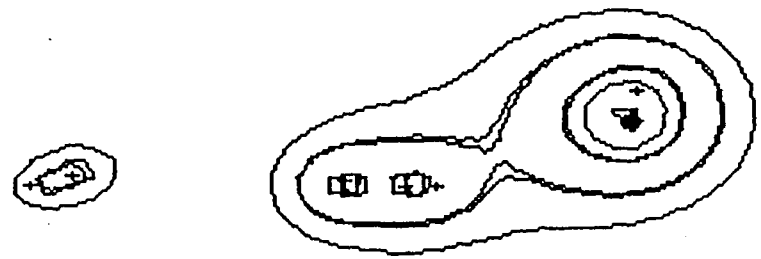
40,40

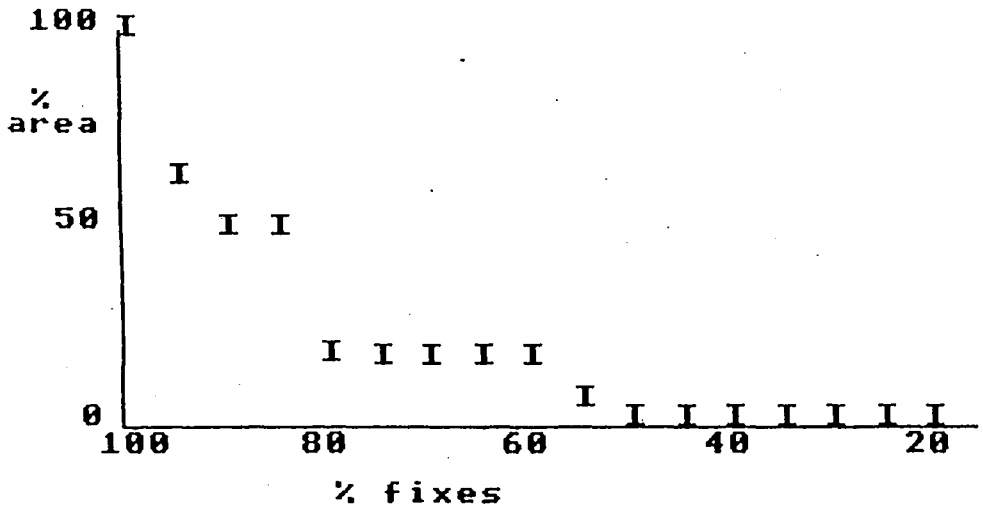
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE14 7/93 (N=15)
Isopleth Areas  Max = 1032.63 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 647.14 | (62.67) | 55 | 70.37 | (6.81) |
| 90 | 516.58 | (50.03) | 50 | 22.46 | (2.18) |
| 85 | 516.58 | (50.03) | 45 | 22.46 | (2.18) |
| 80 | 190.02 | (18.40) | 40 | 22.46 | (2.18) |
| 75 | 178.00 | (17.24) | 35 | 22.46 | (2.18) |
| 70 | 178.00 | (17.24) | 30 | 22.46 | (2.18) |
| 65 | 178.00 | (17.24) | 25 | 22.46 | (2.18) |
| 60 | 181.89 | (17.61) | 20 | 22.46 | (2.18) |

Nugget Creek adult female
Chatham Area






10m

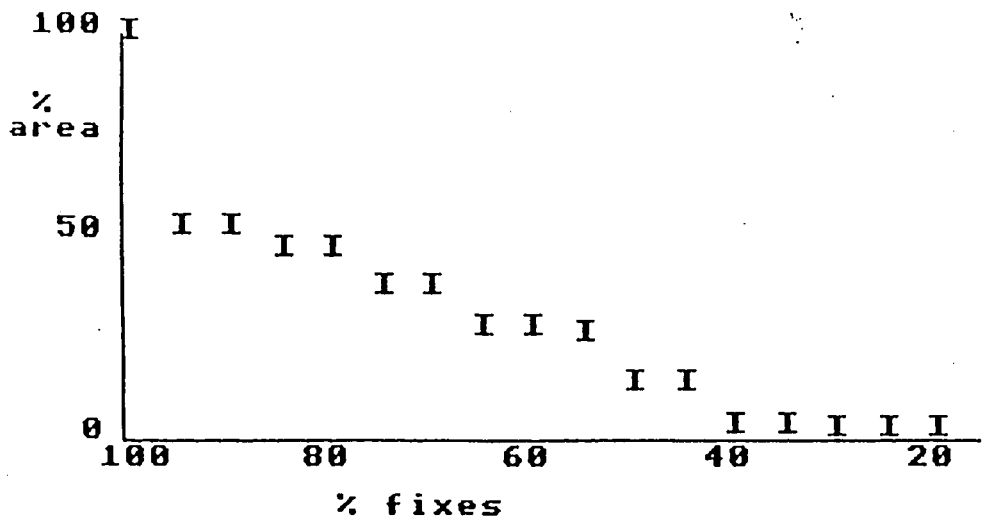
40,40

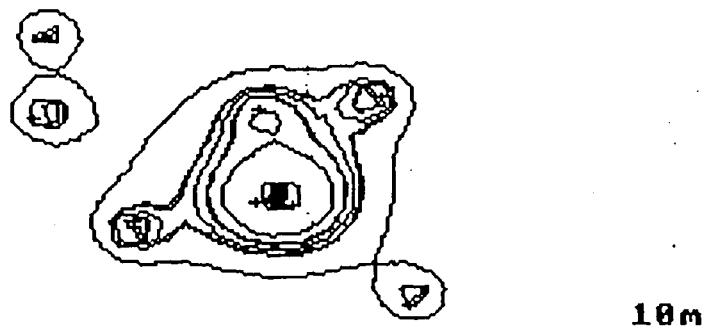
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE17 7/93 (N=11)
Isopleth Areas  Max = 3050.99 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 1608.04 (52.71) | 55 | 805.07 (26.39) |
| 90 | 1608.04 (52.71) | 50 | 435.12 (14.26) |
| 85 | 1433.20 (46.97) | 45 | 435.12 (14.26) |
| 80 | 1433.20 (46.97) | 40 | 116.85 (3.83) |
| 75 | 1149.14 (37.66) | 35 | 116.85 (3.83) |
| 70 | 1149.14 (37.66) | 30 | 77.90 (2.55) |
| 65 | 861.81 (28.25) | 25 | 77.90 (2.55) |
| 60 | 861.81 (28.25) | 20 | 77.90 (2.55) |

Nugget Creek adult male
Chatham Area

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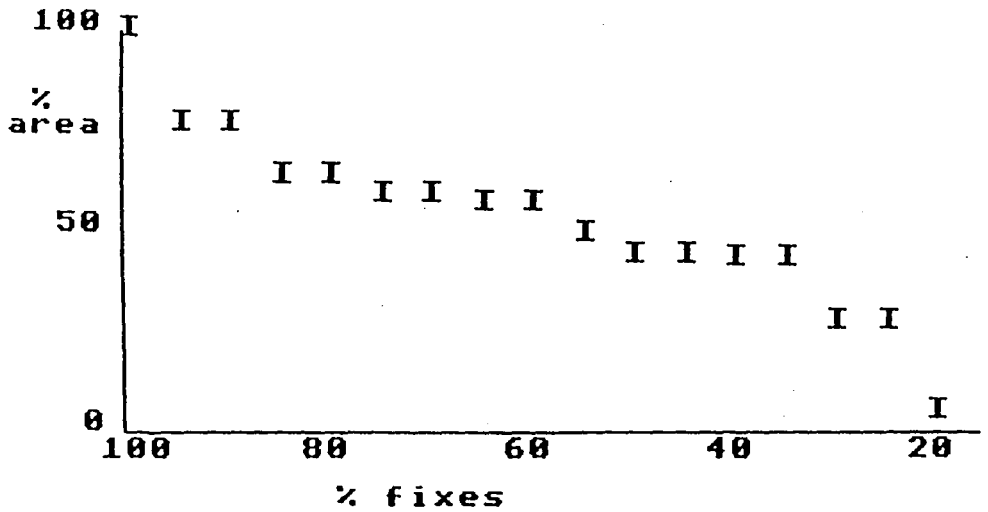
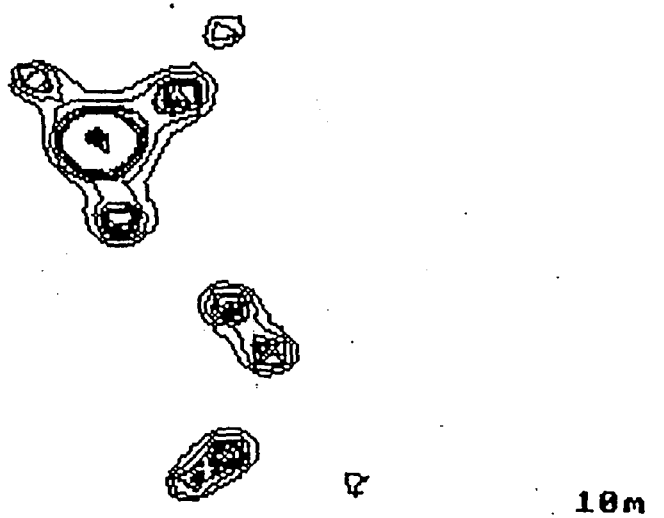
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE18 7/93 (N=11)
Isopleth Areas  Max = 110.45 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 84.32 (76.35) | 55 | 54.43 (49.28) |
| 90 | 84.32 (76.35) | 50 | 48.37 (43.79) |
| 85 | 70.03 (63.41) | 45 | 48.37 (43.79) |
| 80 | 70.03 (63.41) | 40 | 47.62 (43.11) |
| 75 | 65.27 (59.09) | 35 | 47.62 (43.11) |
| 70 | 65.27 (59.09) | 30 | 29.64 (26.84) |
| 65 | 63.27 (57.28) | 25 | 29.64 (26.84) |
| 60 | 63.27 (57.28) | 20 | 5.96 (5.40) |




Point Bridget adult female
Chatham Area

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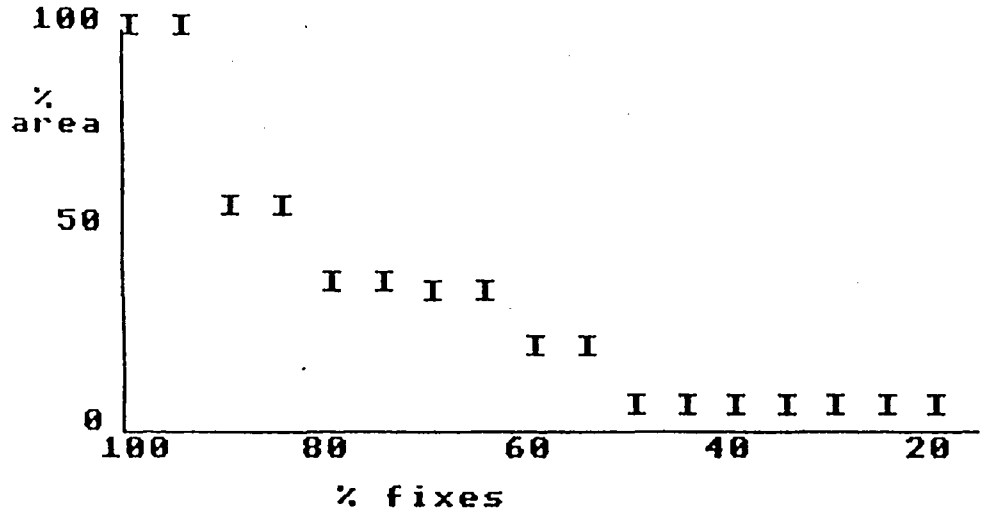
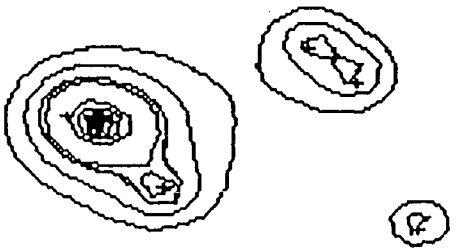
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE19 7/93 (N=9)
Isopleth Areas  Max = 2191.83 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 2191.83 (100.00) | 55 | 443.96 (20.26) |
| 90 | 1218.59 (55.60) | 50 | 128.76 (5.87) |
| 85 | 1218.59 (55.60) | 45 | 128.76 (5.87) |
| 80 | 797.49 (36.38) | 40 | 128.76 (5.87) |
| 75 | 797.49 (36.38) | 35 | 124.10 (5.66) |
| 70 | 749.10 (34.18) | 30 | 124.10 (5.66) |
| 65 | 749.10 (34.18) | 25 | 123.73 (5.64) |
| 60 | 443.96 (20.26) | 20 | 123.73 (5.64) |




Point Bridget adult male
Chatham Area



10m

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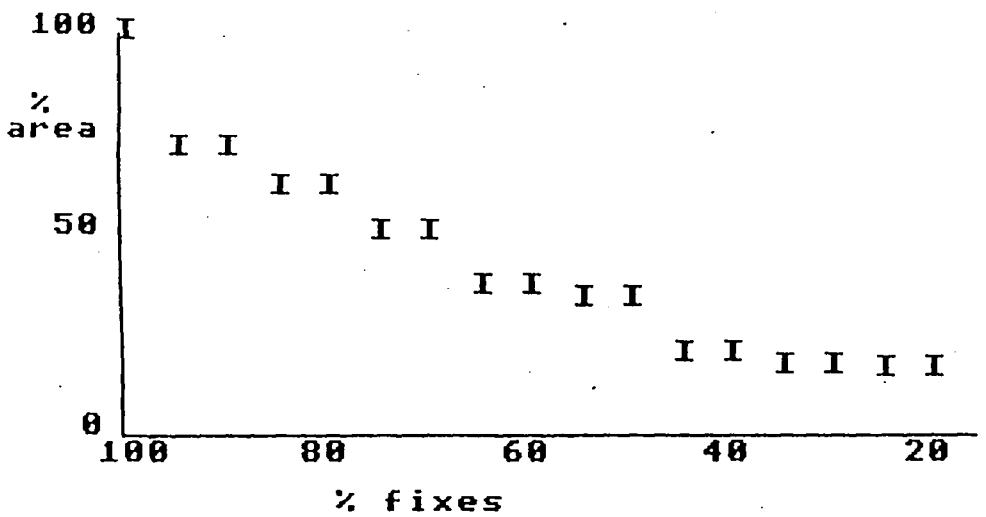
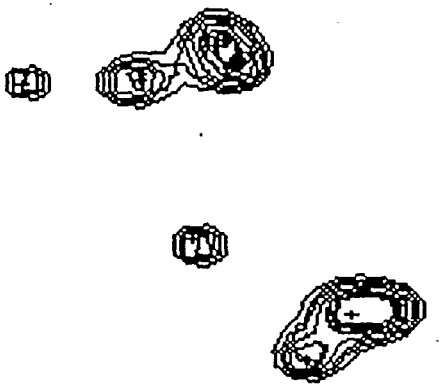
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE22 7/92 (N=10)
Isopleth Areas  Max = 194.79 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 139.50 | (71.62) | 55 | 65.15 | (33.45) |
| 90 | 139.50 | (71.62) | 50 | 65.15 | (33.45) |
| 85 | 120.17 | (61.69) | 45 | 37.67 | (19.34) |
| 80 | 120.17 | (61.69) | 40 | 37.67 | (19.34) |
| 75 | 97.08 | (49.84) | 35 | 32.46 | (16.66) |
| 70 | 97.08 | (49.84) | 30 | 32.46 | (16.66) |
| 65 | 70.09 | (35.98) | 25 | 30.44 | (15.63) |
| 60 | 70.09 | (35.98) | 20 | 30.44 | (15.63) |




Ready Bullion adult female
Chatham Area



10m

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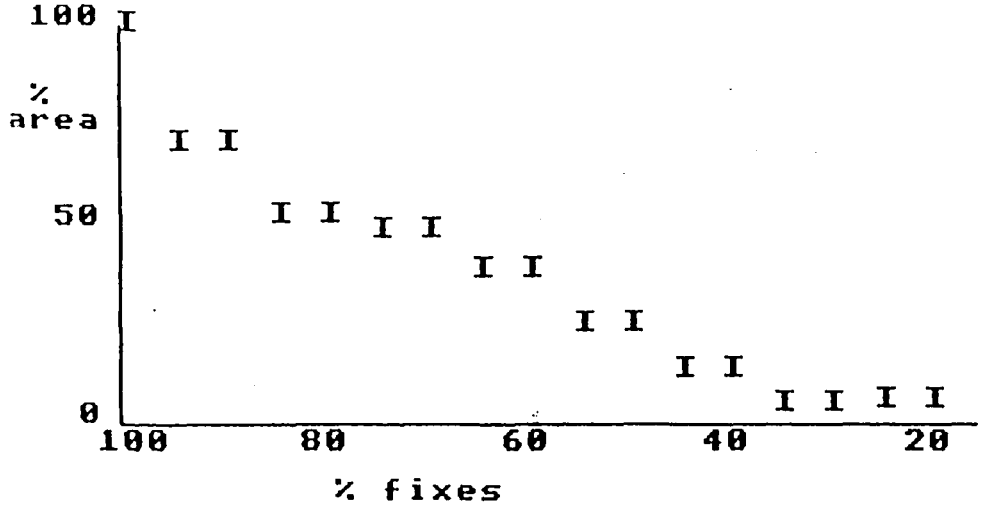
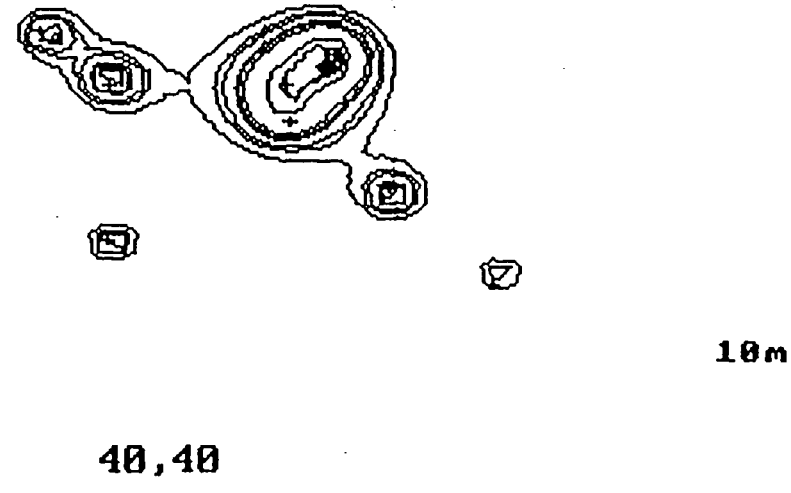
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE24 7/92 (N=10)
Isopleth Areas  Max = 952.21 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 671.97 | (70.57) | 55 | 237.09 | (24.90) |
| 90 | 671.97 | (70.57) | 50 | 237.09 | (24.90) |
| 85 | 497.23 | (52.22) | 45 | 127.60 | (13.40) |
| 80 | 497.23 | (52.22) | 40 | 127.60 | (13.40) |
| 75 | 463.06 | (48.63) | 35 | 49.67 | (5.22) |
| 70 | 463.06 | (48.63) | 30 | 49.67 | (5.22) |
| 65 | 368.76 | (38.73) | 25 | 55.65 | (5.84) |
| 60 | 368.76 | (38.73) | 20 | 55.65 | (5.84) |




Ready Bullion adult male
Chatham Area

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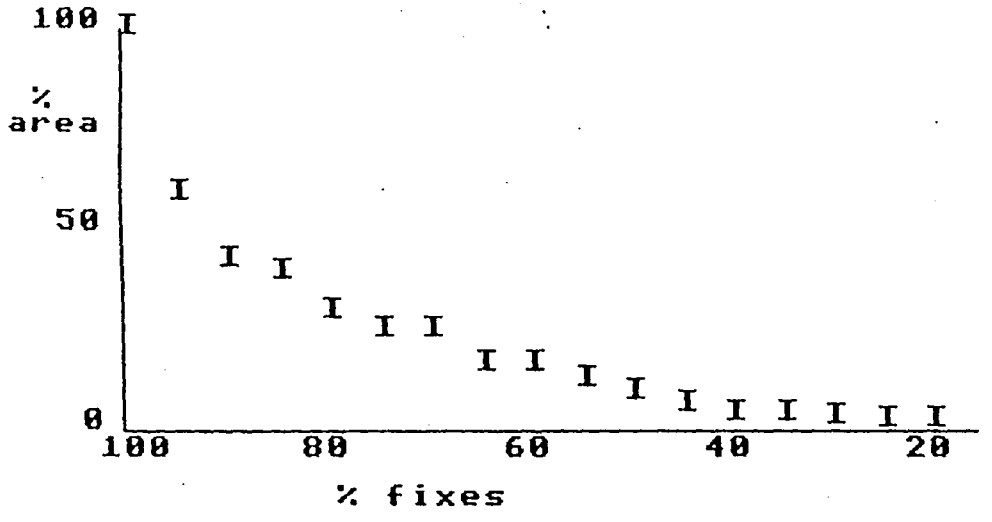
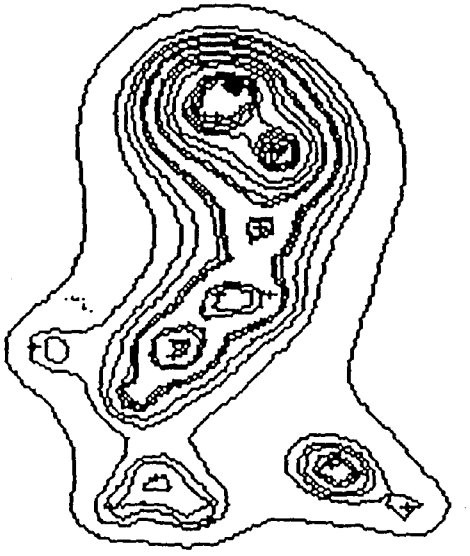
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE25 7/93 (N=25)
Isopleth Areas  Max = 14187.56 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 8362.92 (58.95) | 55 | 1840.63 (12.97) |
| 90 | 6020.65 (42.44) | 50 | 1345.15 (9.48) |
| 85 | 5586.77 (39.38) | 45 | 967.96 (6.82) |
| 80 | 4178.75 (29.45) | 40 | 652.72 (4.60) |
| 75 | 3575.57 (25.20) | 35 | 606.57 (4.28) |
| 70 | 3484.79 (24.56) | 30 | 464.55 (3.27) |
| 65 | 2341.41 (16.50) | 25 | 422.97 (2.98) |
| 60 | 2302.49 (16.23) | 20 | 445.64 (3.14) |




Rowan adult female
Stikine Area



10m

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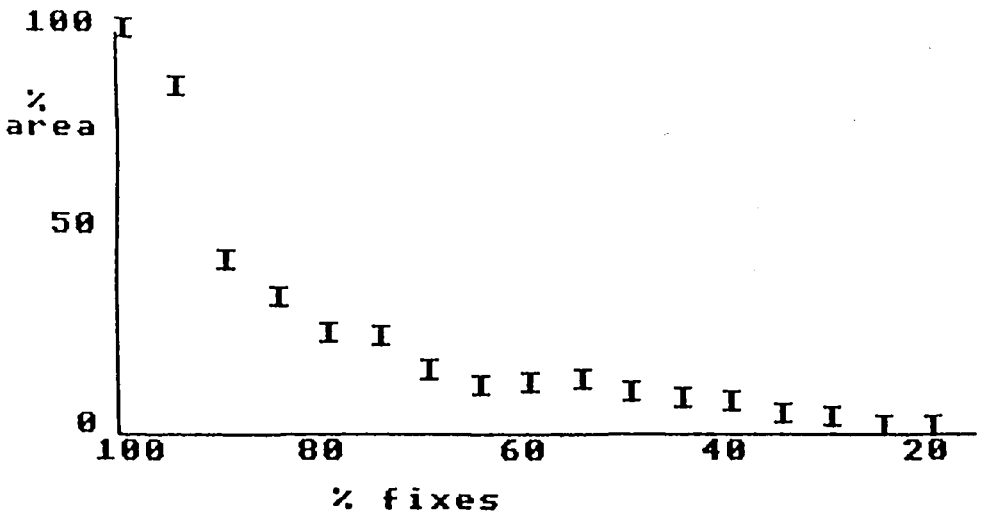
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE28 7/93 (N=25)
Isopleth Areas  Max = 7033.85 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 6045.40 (85.95) | 55 | 885.64 (12.59) |
| 90 | 3009.84 (42.79) | 50 | 681.25 (9.69) |
| 85 | 2316.65 (32.94) | 45 | 573.26 (8.15) |
| 80 | 1722.05 (24.48) | 40 | 527.93 (7.51) |
| 75 | 1629.23 (23.16) | 35 | 329.90 (4.69) |
| 70 | 1054.17 (14.99) | 30 | 260.85 (3.71) |
| 65 | 809.99 (11.52) | 25 | 111.06 (1.58) |
| 60 | 825.78 (11.74) | 20 | 89.41 (1.27) |




Rowan adult male
Stikine Area

10m

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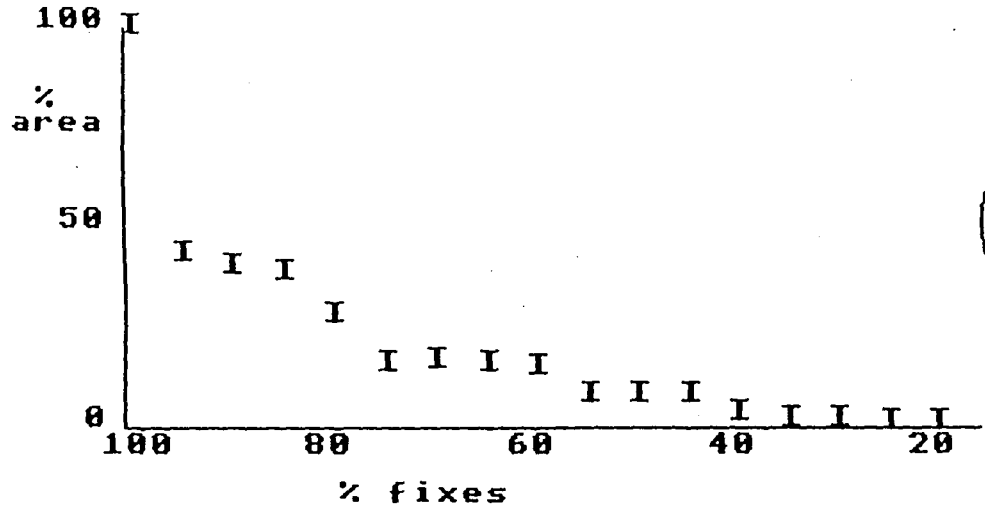
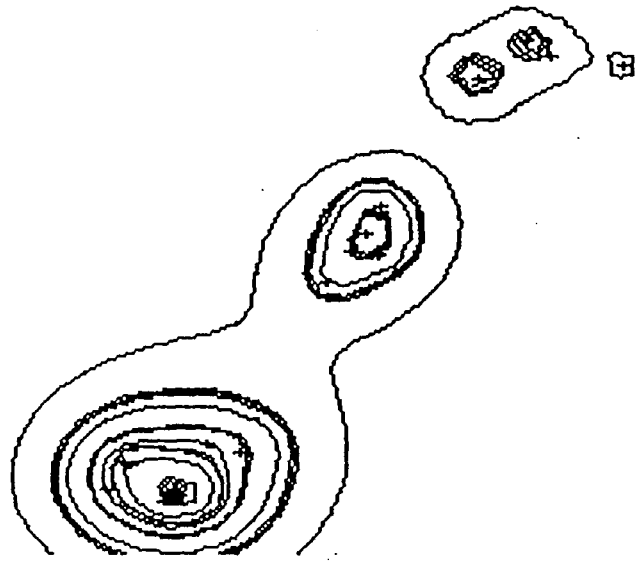
PRESS RETURN (OR Prt Sc KEY)(1)

Sarkar Lake adult female
Ketchikan Area

ADULTFEMALE29 7/92 (N=26)
Isopleth Areas  Max = 48747.46 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 20871.34 (42.82) | 55 | 3841.31 (7.88) |
| 90 | 19613.31 (40.23) | 50 | 3917.06 (8.04) |
| 85 | 18665.48 (38.29) | 45 | 4073.47 (8.36) |
| 80 | 13701.05 (28.11) | 40 | 1858.10 (3.81) |
| 75 | 7562.00 (15.51) | 35 | 815.16 (1.67) |
| 70 | 7890.08 (16.19) | 30 | 815.16 (1.67) |
| 65 | 7837.01 (16.08) | 25 | 707.86 (1.45) |
| 60 | 7303.88 (14.98) | 20 | 707.86 (1.45) |

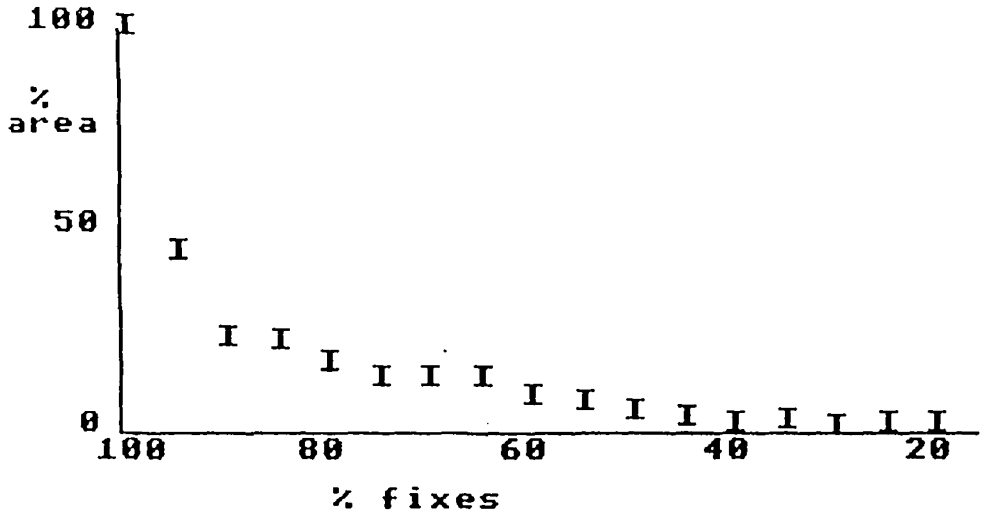


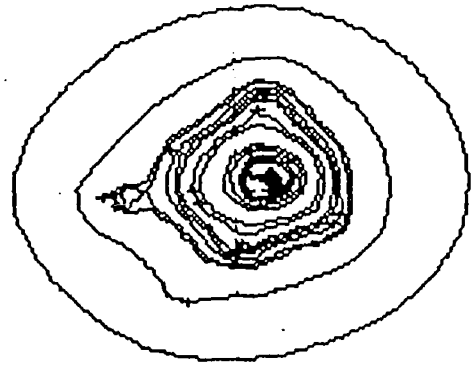

PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE30 7/92 (N=38)
Isopleth Areas  Max = 44311.87 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 19823.88 (44.74) | 55 | 3146.05 (7.10) |
| 90 | 10378.17 (23.42) | 50 | 2305.36 (5.20) |
| 85 | 9997.52 (22.56) | 45 | 1719.78 (3.88) |
| 80 | 7664.84 (17.30) | 40 | 1025.28 (2.31) |
| 75 | 5966.42 (13.46) | 35 | 1103.52 (2.49) |
| 70 | 5914.32 (13.35) | 30 | 702.17 (1.58) |
| 65 | 6026.34 (13.60) | 25 | 812.61 (1.83) |
| 60 | 4071.46 (9.19) | 20 | 812.61 (1.83) |




Sarkar Lake adult male
Ketchikan Area



10m

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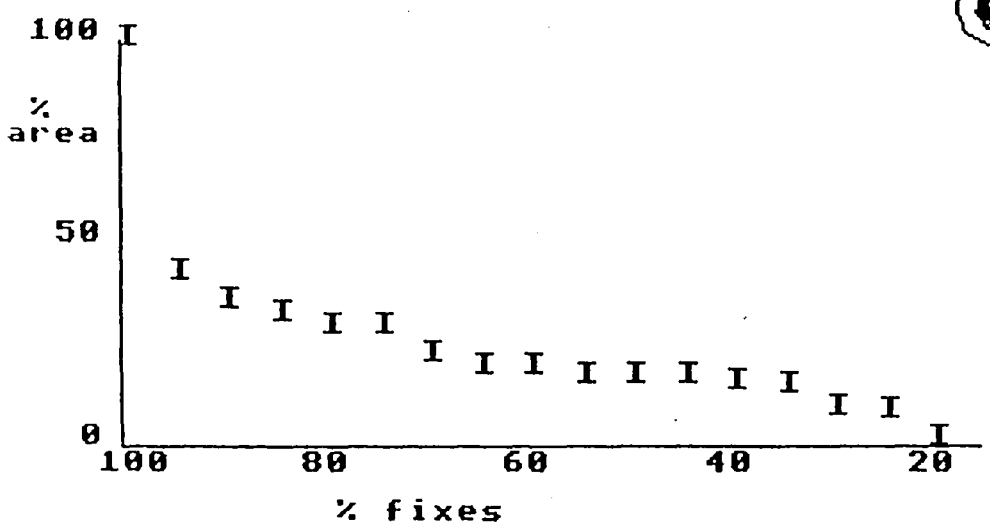
PRESS RETURN (OR Prt Sc KEY)(1)

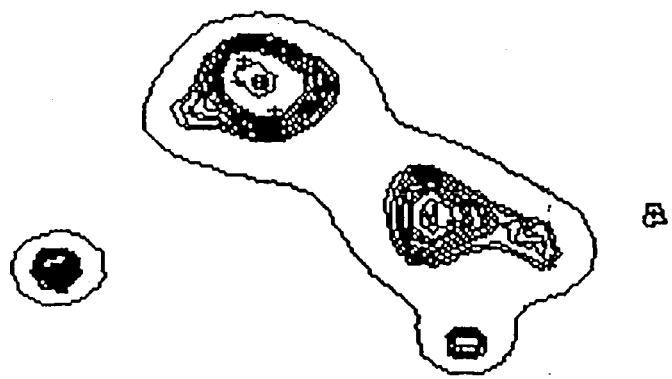
**Appendix III.** Adult northern goshawk total harmonic mean home ranges at 5% isopleth intervals (in hectares) as determined by RANGES IV (Kenward 1990). Total home range size based on independent radio-telemetry relocations from both nesting and post-nesting periods up to Novemb 1993. With the exception of SLF1 (16 months), SLM1 (9 months), RBF1 (6 months) and RBM1 months) which were radio-tagged in 1992, total home ranges were constructed using data collected during the 3-5 month period between June and November 1993.

ADULTFEMALE1 7/93 (N=19)
Isopleth Areas  Max = 3346.20 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 1426.55 (42.63) | 55 | 572.86 (17.12) |
| 90 | 1201.05 (35.89) | 50 | 572.86 (17.12) |
| 85 | 1076.42 (32.17) | 45 | 572.86 (17.12) |
| 80 | 990.20 (29.59) | 40 | 533.78 (15.95) |
| 75 | 990.20 (29.59) | 35 | 512.45 (15.31) |
| 70 | 750.70 (22.43) | 30 | 325.30 (9.72) |
| 65 | 655.89 (19.60) | 25 | 304.25 (9.09) |
| 60 | 644.28 (19.25) | 20 | 77.52 (2.32) |

Blueberry adult female
Chatham Area



10m

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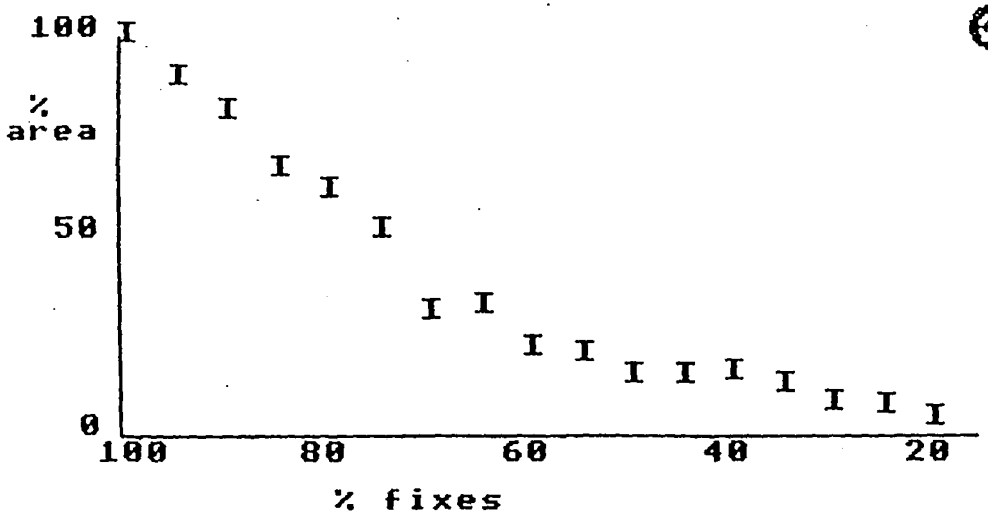
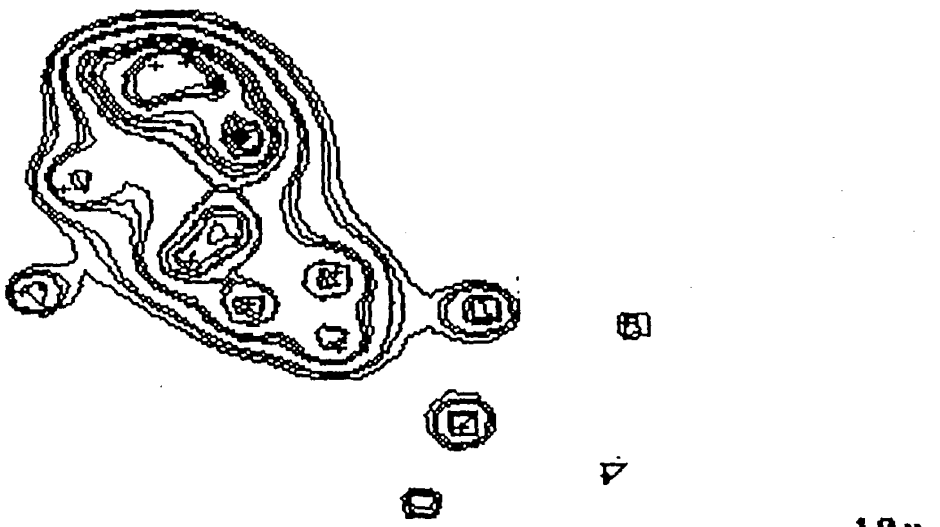
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE3 7/93 (N=19)
Isopleth Areas  Max = 2587.19 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 2325.31 | (89.88) | 55 | 530.59 | (20.51) |
| 90 | 2098.66 | (81.12) | 50 | 395.53 | (15.29) |
| 85 | 1727.49 | (66.77) | 45 | 395.53 | (15.29) |
| 80 | 1592.68 | (61.56) | 40 | 402.94 | (15.57) |
| 75 | 1343.04 | (51.91) | 35 | 320.13 | (12.37) |
| 70 | 805.80 | (31.15) | 30 | 217.18 | (8.39) |
| 65 | 846.50 | (32.72) | 25 | 182.78 | (7.06) |
| 60 | 557.18 | (21.54) | 20 | 107.96 | (4.17) |




Blueberry adult male
Chatham Area



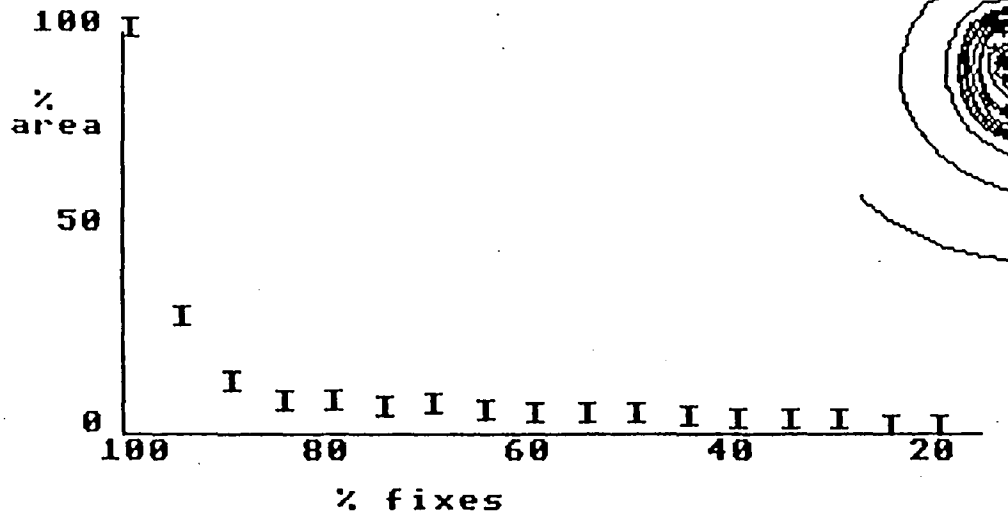

40,40

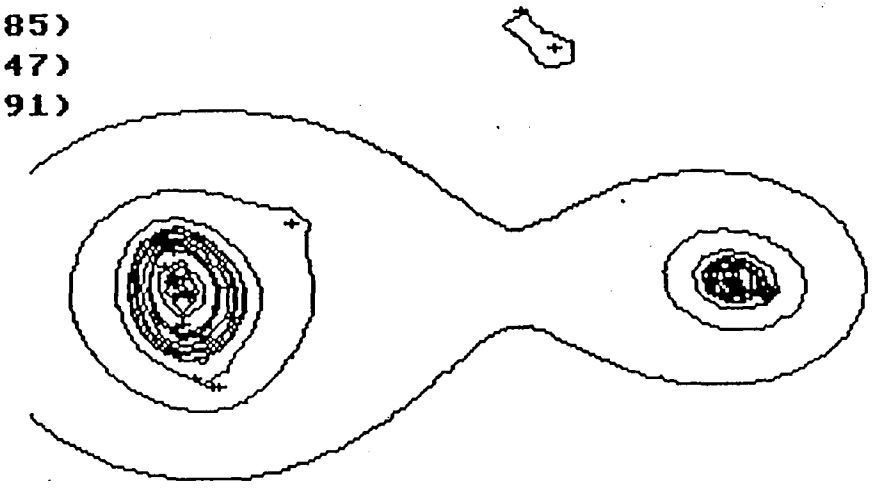
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE4 7/93 (N=47)
Isopleth Areas  Max = 213750.59 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 59786.74 (27.97) | 55 | 8814.90 (4.12) |
| 90 | 25760.74 (12.05) | 50 | 8814.90 (4.12) |
| 85 | 16207.42 (7.58) | 45 | 7283.35 (3.41) |
| 80 | 15360.06 (7.19) | 40 | 5808.67 (2.72) |
| 75 | 13068.97 (6.11) | 35 | 5808.67 (2.72) |
| 70 | 13420.58 (6.28) | 30 | 6084.84 (2.85) |
| 65 | 11489.48 (5.38) | 25 | 3136.91 (1.47) |
| 60 | 8814.90 (4.12) | 20 | 1940.59 (0.91) |

BigJohn adult female
Stikine Area



10m

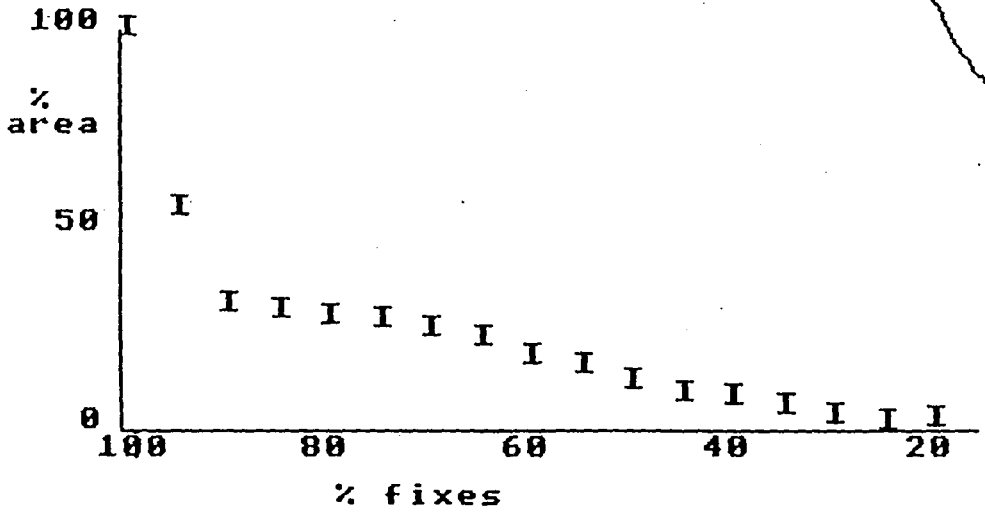
40,40

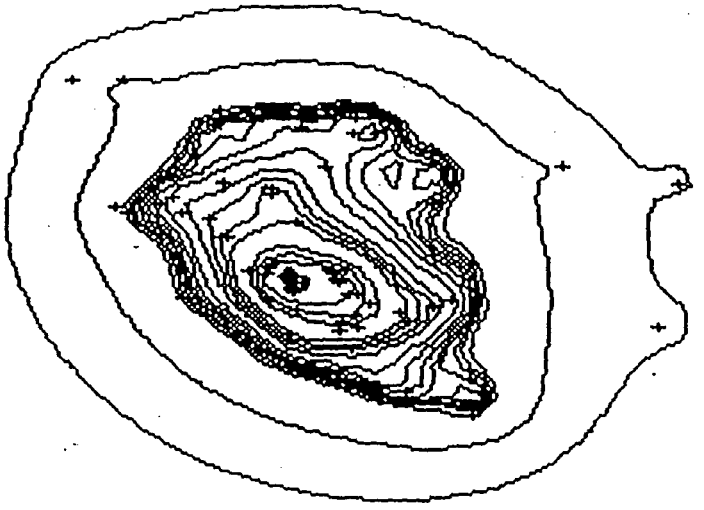
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE6 7/93 (N=77)
Isopleth Areas  Max = 34565.87 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 19013.02 | (55.01) | 55 | 5566.75 | (16.10) |
| 90 | 10807.01 | (31.26) | 50 | 4077.05 | (11.80) |
| 85 | 10124.87 | (29.29) | 45 | 3024.17 | (8.75) |
| 80 | 9604.56 | (27.79) | 40 | 2838.22 | (8.21) |
| 75 | 9315.21 | (26.95) | 35 | 1936.25 | (5.60) |
| 70 | 8645.82 | (25.01) | 30 | 1129.00 | (3.27) |
| 65 | 7801.71 | (22.57) | 25 | 701.12 | (2.03) |
| 60 | 6296.86 | (18.22) | 20 | 840.44 | (2.43) |

Big John adult male
Stikine Area



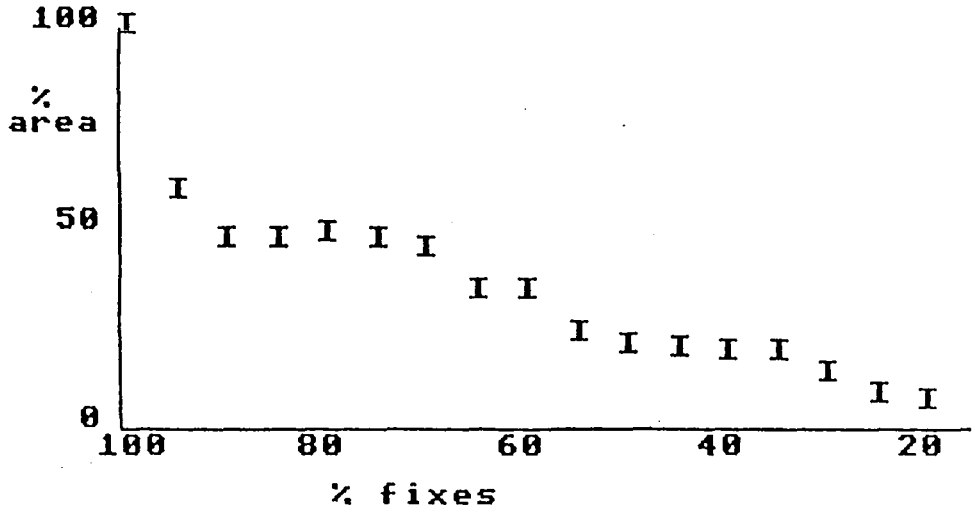
10m

40,40

PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE8 7/93 (N=16)
Isopleth Areas  Max = 4886.16 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 2909.99 (59.56) | 55 | 1128.22 (23.09) |
| 90 | 2313.53 (47.35) | 50 | 983.46 (20.13) |
| 85 | 2313.53 (47.35) | 45 | 974.45 (19.94) |
| 80 | 2356.59 (48.23) | 40 | 902.10 (18.46) |
| 75 | 2312.94 (47.34) | 35 | 902.10 (18.46) |
| 70 | 2192.24 (44.87) | 30 | 665.88 (13.63) |
| 65 | 1654.78 (33.87) | 25 | 413.09 (8.45) |
| 60 | 1654.78 (33.87) | 20 | 339.16 (6.94) |




Eagle Creek adult female
Chatham Area

10m

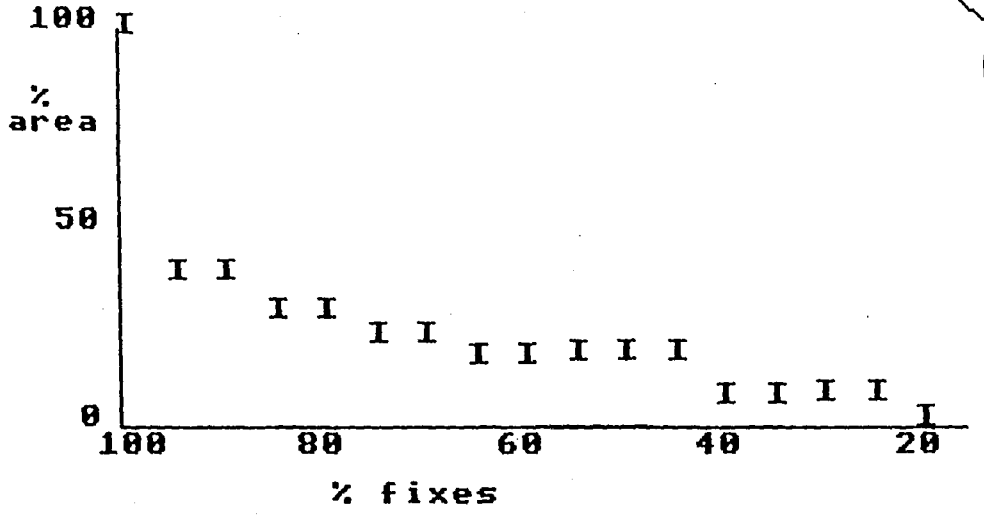
40,40

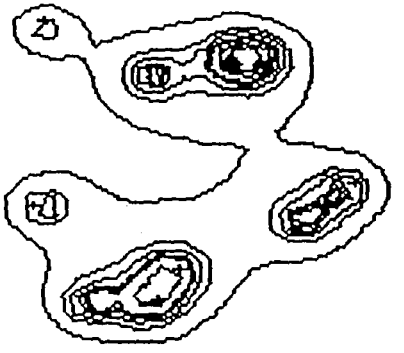
PRESS RETURN (OR Prt Sc KEY)(1)

Eagle Creek adult male
Chatham Area

ADULTMALE9 7/93 (N=11)
Isopleth Areas  Max = 698.93 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 271.59 | (38.86) | 55 | 125.71 | (17.99) |
| 90 | 271.59 | (38.86) | 50 | 127.62 | (18.26) |
| 85 | 199.36 | (28.52) | 45 | 127.62 | (18.26) |
| 80 | 199.36 | (28.52) | 40 | 49.87 | (7.14) |
| 75 | 158.22 | (22.64) | 35 | 49.87 | (7.14) |
| 70 | 158.22 | (22.64) | 30 | 54.90 | (7.86) |
| 65 | 122.73 | (17.56) | 25 | 54.90 | (7.86) |
| 60 | 122.73 | (17.56) | 20 | 13.82 | (1.98) |



10m

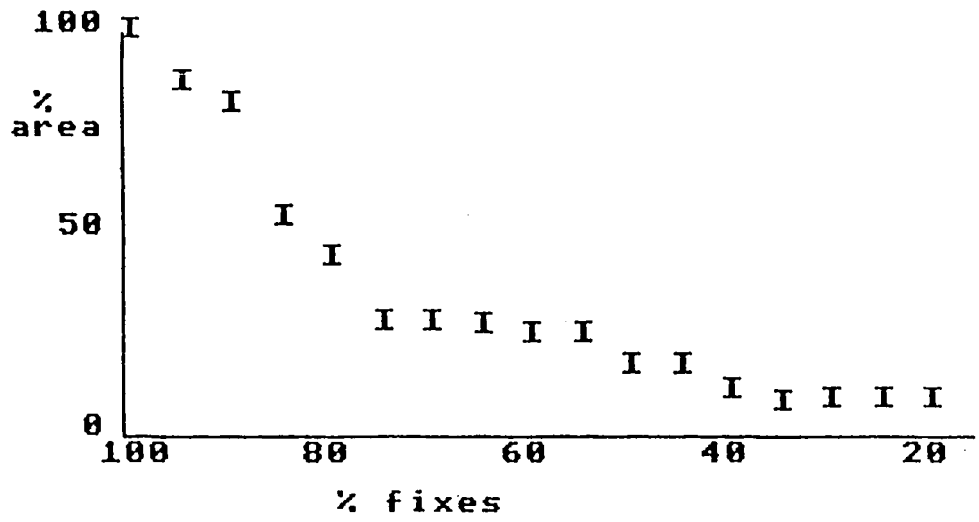
40,40

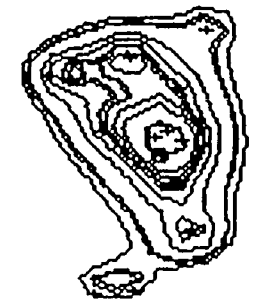
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE12 7/93 (N=22)
Isopleth Areas  Max = 10819.08 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 9427.20 | (87.13) | 55 | 2666.17 | (24.64) |
| 90 | 8898.75 | (82.25) | 50 | 1896.48 | (17.53) |
| 85 | 5865.37 | (54.21) | 45 | 1896.48 | (17.53) |
| 80 | 4716.48 | (43.59) | 40 | 1206.81 | (11.15) |
| 75 | 3014.41 | (27.86) | 35 | 846.83 | (7.83) |
| 70 | 3014.41 | (27.86) | 30 | 928.55 | (8.58) |
| 65 | 2934.24 | (27.12) | 25 | 928.55 | (8.58) |
| 60 | 2700.05 | (24.96) | 20 | 928.55 | (8.58) |

Logjam adult male
Ketchikan Area



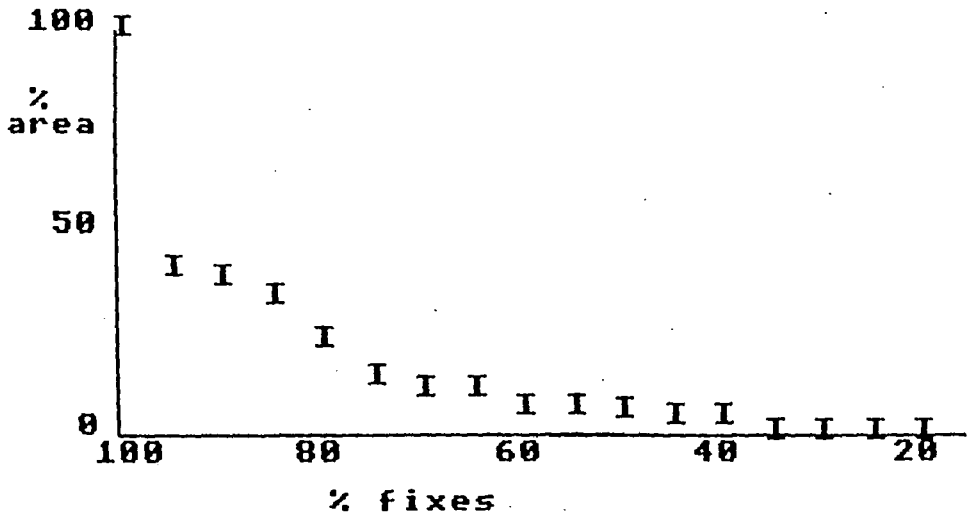
10m

40,40

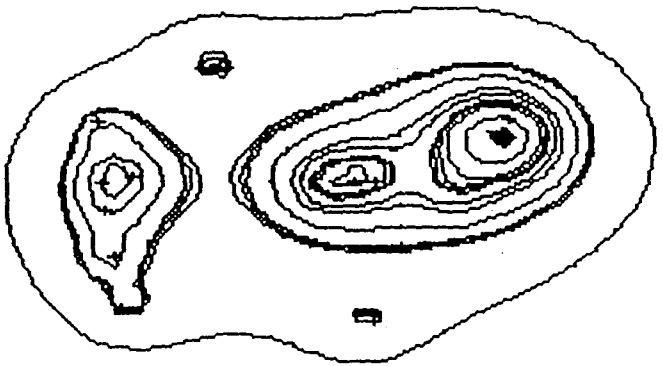
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE14 7/93 (N=22)
Isopleth Areas  Max = 5054.80 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 2048.65 (40.53) | 55 | 324.52 (6.42) |
| 90 | 1939.67 (38.37) | 50 | 312.51 (6.18) |
| 85 | 1735.81 (34.34) | 45 | 220.92 (4.37) |
| 80 | 1191.16 (23.56) | 40 | 220.92 (4.37) |
| 75 | 704.37 (13.93) | 35 | 33.32 (0.66) |
| 70 | 557.07 (11.02) | 30 | 27.87 (0.55) |
| 65 | 564.25 (11.16) | 25 | 27.87 (0.55) |
| 60 | 315.32 (6.24) | 20 | 27.87 (0.55) |




Nugget Creek adult female
Chatham Area



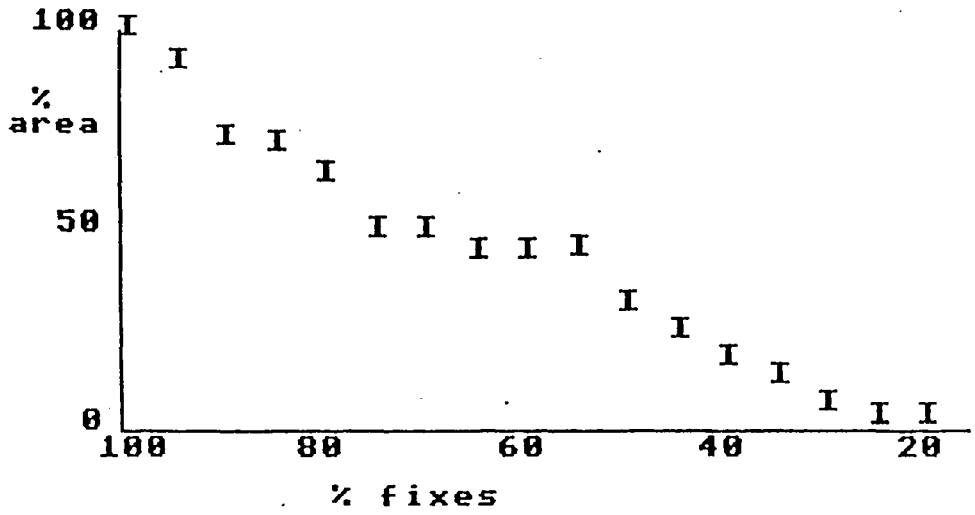
10m

40,40

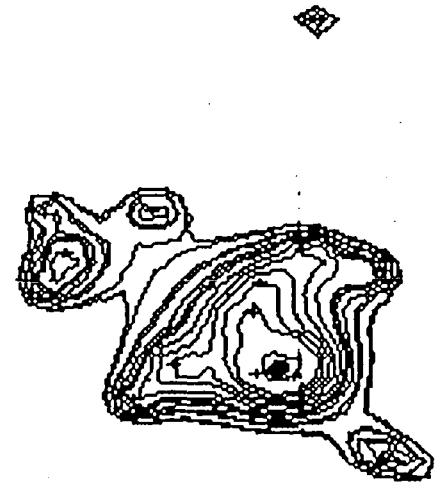
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE17 7/93 (N=18)
Isopleth Areas  Max = 3117.55 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 2878.39 | (92.33) | 55 | 1412.02 | (45.29) |
| 90 | 2267.23 | (72.72) | 50 | 993.57 | (31.87) |
| 85 | 2218.07 | (71.15) | 45 | 784.22 | (25.16) |
| 80 | 1990.83 | (63.86) | 40 | 564.65 | (18.11) |
| 75 | 1558.82 | (50.00) | 35 | 427.67 | (13.72) |
| 70 | 1558.82 | (50.00) | 30 | 200.23 | (6.42) |
| 65 | 1393.99 | (44.71) | 25 | 118.55 | (3.80) |
| 60 | 1387.33 | (44.50) | 20 | 118.55 | (3.80) |




Nugget Creek adult male
Chatham Area



10m

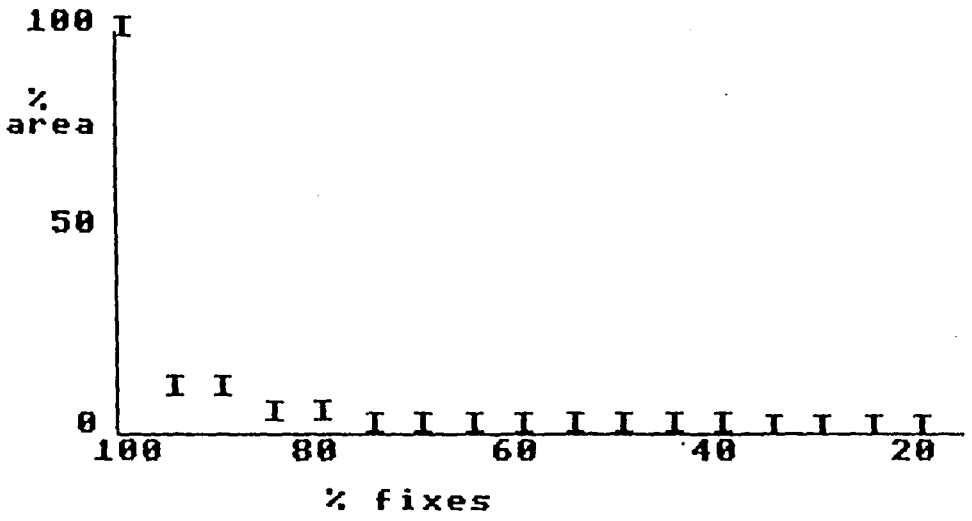
40,40

PRESS RETURN (OR Prt Sc KEY)(1)

Point Bridget adult female
Chatham Area

ADULTFEMALE18 7/93 (N=14)
Isopleth Areas  Max = 48197.13 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 5304.21 (11.01) | 55 | 996.24 (2.07) |
| 90 | 5304.21 (11.01) | 50 | 996.24 (2.07) |
| 85 | 2336.04 (4.85) | 45 | 996.24 (2.07) |
| 80 | 2336.04 (4.85) | 40 | 996.24 (2.07) |
| 75 | 996.24 (2.07) | 35 | 727.22 (1.51) |
| 70 | 996.24 (2.07) | 30 | 727.22 (1.51) |
| 65 | 996.24 (2.07) | 25 | 727.22 (1.51) |
| 60 | 996.24 (2.07) | 20 | 727.22 (1.51) |

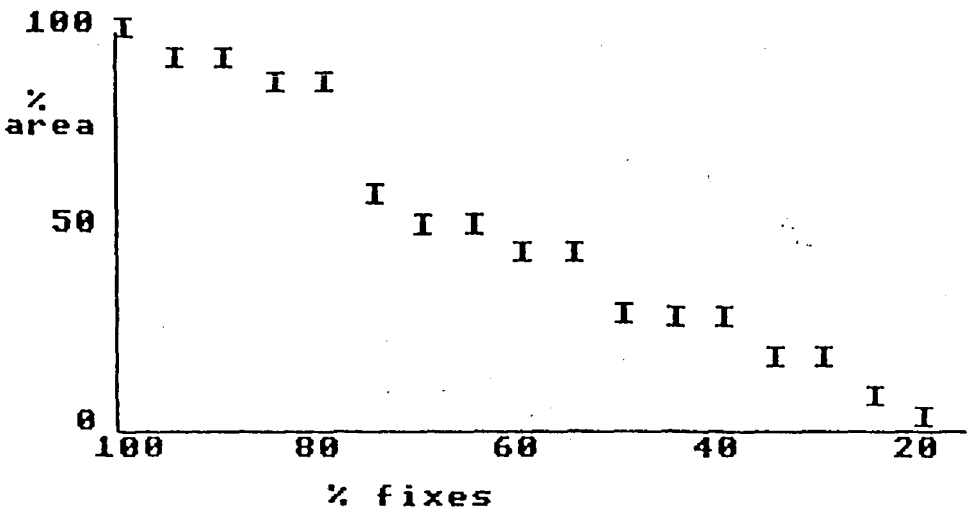


40,40

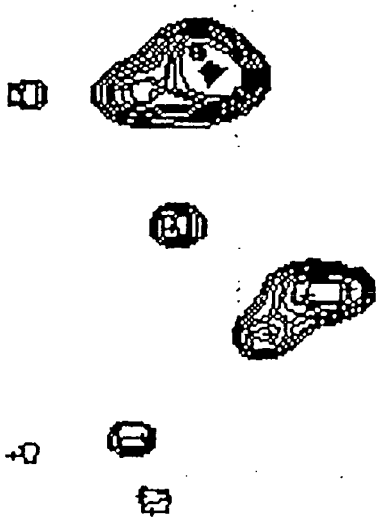
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE22 7/92 (N=12)
Isopleth Areas  Max = 272.63 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 253.37 | (92.93) | 55 | 120.49 | (44.19) |
| 90 | 253.37 | (92.93) | 50 | 78.65 | (28.85) |
| 85 | 236.52 | (86.75) | 45 | 75.59 | (27.73) |
| 80 | 236.52 | (86.75) | 40 | 75.59 | (27.73) |
| 75 | 159.23 | (58.41) | 35 | 48.76 | (17.88) |
| 70 | 137.72 | (50.51) | 30 | 48.76 | (17.88) |
| 65 | 137.72 | (50.51) | 25 | 22.37 | (8.20) |
| 60 | 120.49 | (44.19) | 20 | 6.93 | (2.54) |




Ready Bullion adult female
Chatham Area



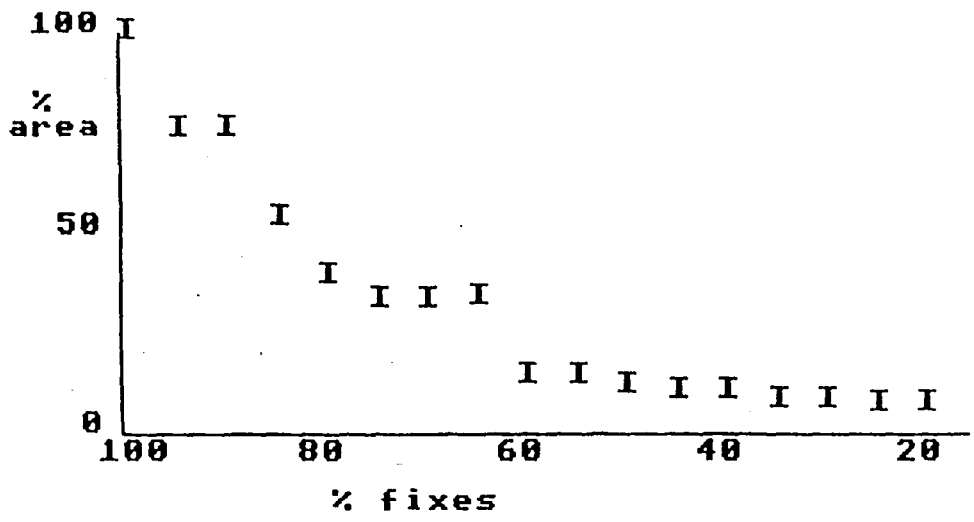
10m

40,40

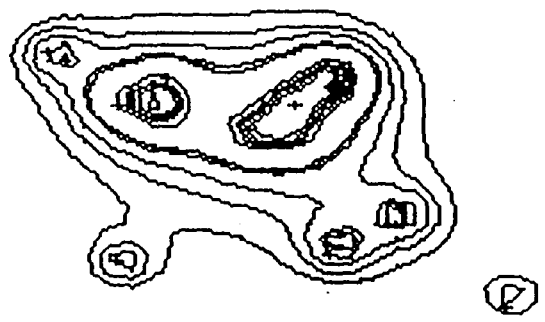
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE24 7/92 (N=14)
Isopleth Areas  Max = 1894.59 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 1445.36 (76.29) | 55 | 268.15 (14.15) |
| 90 | 1445.36 (76.29) | 50 | 233.05 (12.30) |
| 85 | 1013.49 (53.49) | 45 | 191.56 (10.11) |
| 80 | 749.22 (39.55) | 40 | 191.56 (10.11) |
| 75 | 629.09 (33.20) | 35 | 151.75 (8.01) |
| 70 | 629.09 (33.20) | 30 | 156.60 (8.27) |
| 65 | 648.16 (34.21) | 25 | 133.20 (7.03) |
| 60 | 268.15 (14.15) | 20 | 133.20 (7.03) |




Ready Bullion adult male
Chatham Area



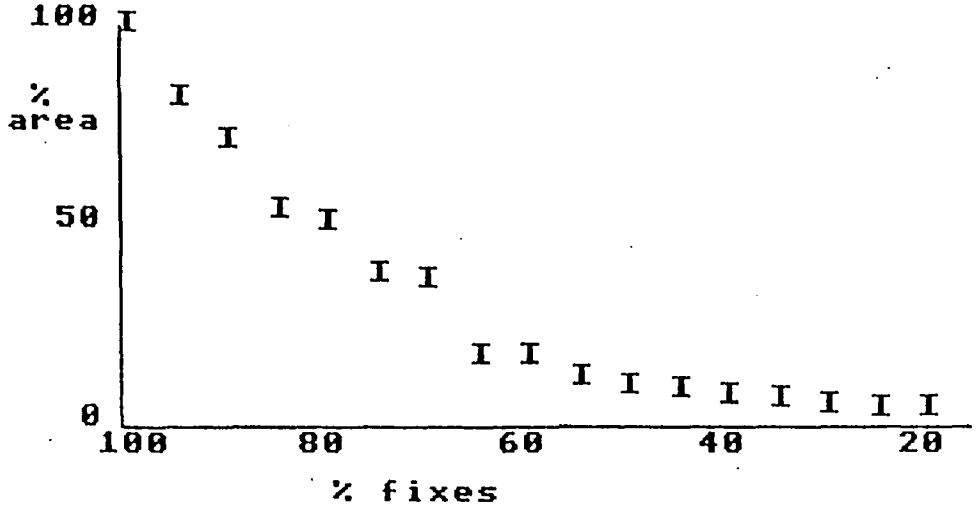
10m

40,40

PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE25 7/93 (N=42)
Isopleth Areas  Max = 20579.18 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 16955.17 (82.39) | 55 | 2412.91 (11.73) |
| 90 | 14666.57 (71.27) | 50 | 2023.86 (9.83) |
| 85 | 11011.25 (53.51) | 45 | 1761.96 (8.56) |
| 80 | 10495.87 (51.00) | 40 | 1544.36 (7.50) |
| 75 | 7713.14 (37.48) | 35 | 1410.43 (6.85) |
| 70 | 7463.97 (36.27) | 30 | 1072.27 (5.21) |
| 65 | 3601.16 (17.50) | 25 | 870.14 (4.23) |
| 60 | 3545.46 (17.23) | 20 | 851.02 (4.14) |




Rowan adult female
Stikine Area

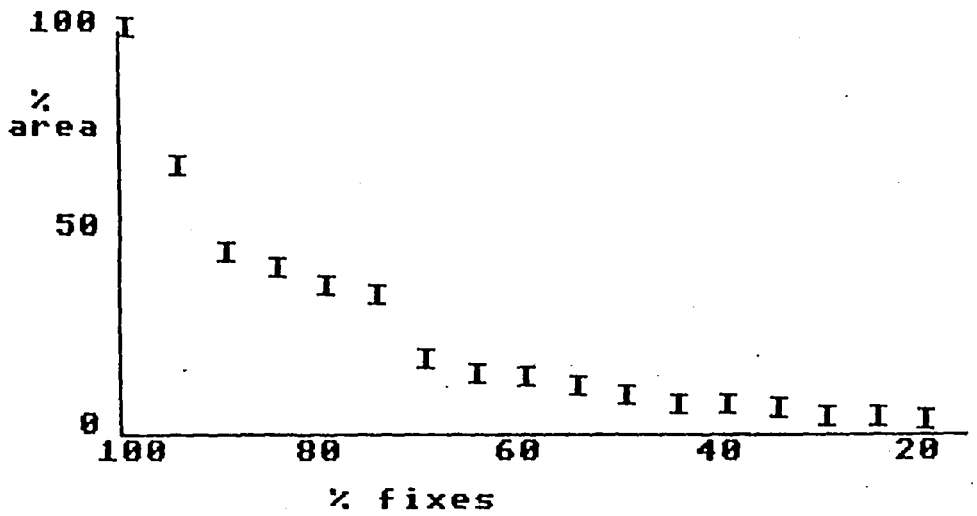
10m

40,40

PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE28 7/93 (N=42)
Isopleth Areas  Max = 9643.82 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 6374.55 | (66.10) | 55 | 1098.45 | (11.39) |
| 90 | 4329.37 | (44.89) | 50 | 838.10 | (8.69) |
| 85 | 3933.74 | (40.79) | 45 | 667.70 | (6.92) |
| 80 | 3481.08 | (36.10) | 40 | 621.71 | (6.45) |
| 75 | 3270.38 | (33.91) | 35 | 533.02 | (5.53) |
| 70 | 1751.67 | (18.16) | 30 | 369.81 | (3.83) |
| 65 | 1350.97 | (14.01) | 25 | 339.35 | (3.52) |
| 60 | 1299.34 | (13.47) | 20 | 301.45 | (3.13) |




Rowan adult male
Stikine Area

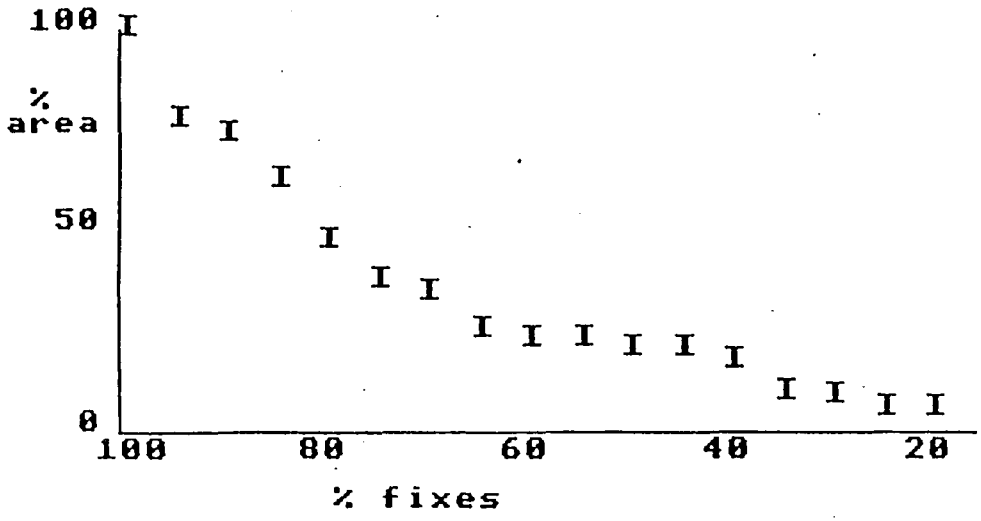
10m

40,40

PRESS RETURN (OR Prt Sc KEY)(1)

ADULTFEMALE29 7/92 (N=71)
Isopleth Areas  Max = 156397.52 ha.

| % | ha. (%max) | % | ha. (%max) |
|---|---|---|---|
| 95 | 120866.31 (77.28) | 55 | 35648.29 (22.79) |
| 90 | 114727.61 (73.36) | 50 | 31422.43 (20.09) |
| 85 | 96757.17 (61.87) | 45 | 32189.78 (20.58) |
| 80 | 72936.84 (46.64) | 40 | 26483.79 (16.93) |
| 75 | 58458.83 (37.38) | 35 | 14769.57 (9.44) |
| 70 | 52887.08 (33.82) | 30 | 14205.15 (9.08) |
| 65 | 38847.79 (24.84) | 25 | 8803.65 (5.63) |
| 60 | 35020.73 (22.39) | 20 | 9003.26 (5.76) |




Sarkar Lake adult female
Ketchikan Area

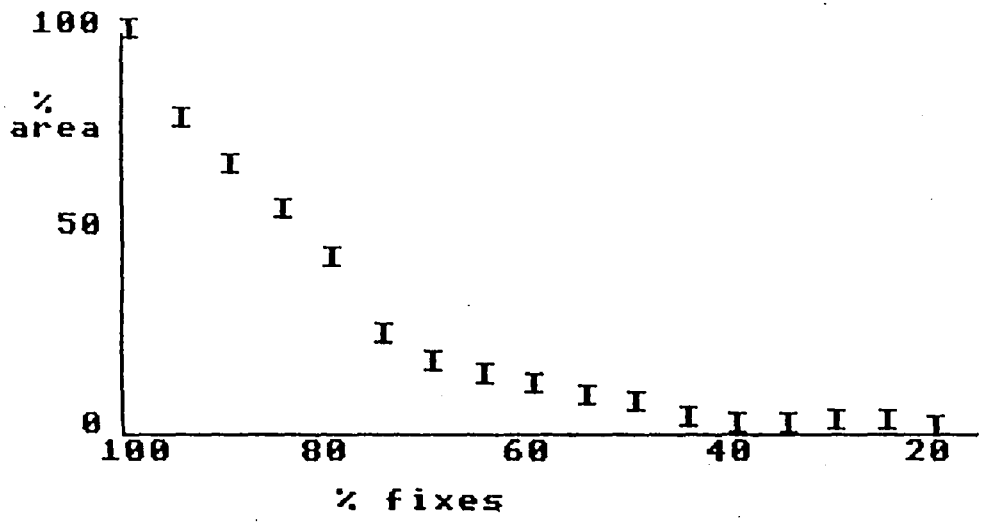
10m

40,40

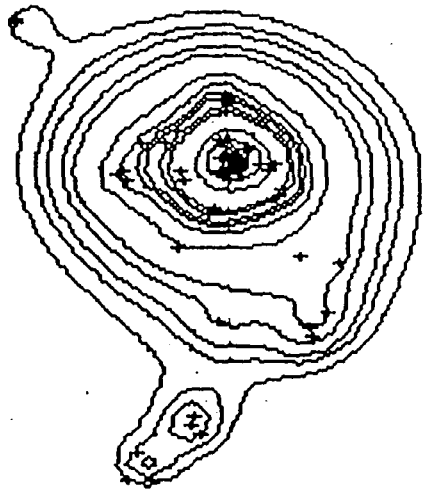
PRESS RETURN (OR Prt Sc KEY)(1)

ADULTMALE30 7/92 (N=56)
Isopleth Areas  Max = 91287.55 ha.

| % | ha. | (%max) | % | ha. | (%max) |
|---|---|---|---|---|---|
| 95 | 71210.30 | (78.01) | 55 | 8336.74 | (9.13) |
| 90 | 60949.46 | (66.77) | 50 | 6990.22 | (7.66) |
| 85 | 50349.78 | (55.16) | 45 | 3097.93 | (3.39) |
| 80 | 39116.51 | (42.85) | 40 | 2118.44 | (2.32) |
| 75 | 22034.30 | (24.14) | 35 | 2118.44 | (2.32) |
| 70 | 16065.82 | (17.60) | 30 | 2260.36 | (2.48) |
| 65 | 13025.21 | (14.27) | 25 | 2260.36 | (2.48) |
| 60 | 11075.97 | (12.13) | 20 | 1022.31 | (1.12) |




Sarkar Lake adult male
Ketchikan Area



10m

40,40

PRESS RETURN (OR Prt Sc KEY)(1)